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DELINEATIONS OF LANDTYPE ASSOCIATIONS FOR NORTHWEST WYOMING AND THE BUFFALO RESOURCE AREA

Bureau of Land Management/University of Wyoming
Contracts K-910-P970194 and K-910-P970206

31 December 1999

William A. Reiners, Ellen V. Axtmann, and Robert C. Thurston

Department of Botany, University of Wyoming

Laramie, Wyoming 82071

FINAL REPORT

UNIVERSITY OF WYOMING

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1. OBJECTIVES OF THE WORK

The objective of this work is to provide a scientifically based, hierarchical, system of map units (*sensu* Bailey 1980) for both northwestern Wyoming and the Buffalo Resource Area (BRA) of northeastern Wyoming that incorporates ecological principles and processes across a range of scales. The work area includes all of Campbell County, and parts of Sheridan, Johnson, Big Horn, Washakie, Hot Springs, Park, Teton, Fremont and Sublette Counties as illustrated in Figure 1.

This report is part of a set of deliverables for the Wyoming State Office of the Bureau of Land Management as required by work orders K-910-P970194 and K-910-P970206. Other deliverables include the delineations as GIS coverages, a hard copy map and slides. Pertinent portions of the description of the work as set forth in these work orders include the following:

"...delineate landscape complexes ("landtype associations" sensu Bailey (1980) and higher order regional units for the BRA in the counties listed..." (K-910-P970194)

"...delineate landscape complexes ("landtype associations" sensu Bailey (1980) and higher order regional units for the northwestern quarter of Wyoming in the counties listed..." (K-910-P970206)

"Work performed under this contract will be "edge-matched" with completed landtype delineation work..." that was produced in earlier contracts with the BLM by the University of Wyoming.

"UW shall, insofar as practicable and possible, include and incorporate available NWWY US Forest Service (FS) ecological mapping data at the landtype association level into the NWWY project final report and mapping. This proviso is intended to make the NWWY final delineation report as comprehensive as possible without changing mapping philosophy and procedures UW has used in prior delineation projects for BLM."

In initial discussions regarding joining USFS map products, BLM and UW participants agreed that comparable National Park Service (NPS) products from Grand Teton National Park and Yellowstone National Park would also be included. UW personnel did communicate with relevant NPS personnel about this possibility but learned that such products, though in production, are not yet available.

The BLM and UW mutually agreed in a meeting on 21 May 1999 that the results for both the NWWY and Buffalo Resource Area work would be joined together in a single report. This decision, along with details on modifications of deliverables was formally authorized in an undated letter from Charles Padilla received some time after that meeting.

As a result of these modifications, this is a combined report for both northwestern Wyoming and the revised Buffalo Resource Area. This report refers to associated deliverables and to USFS map products that were available at the time of this writing.

This work is a continuation of related work with the Wyoming State Office of the Bureau of Land Management in which we delimited land units in northeastern, southwestern and southeastern Wyoming (Reiners and Thurston 1994, 1995, 1996, 1997). The products described in this report, together with the incorporation of land unit delineations provided by the various national forests and national parks of Wyoming, is meant to complete Landtype Association (LTA) mapping for the entire state.

2. PHILOSOPHY OF THE WORK

2.1 Mapping Landtype Associations

The goal of this and our previous work for BLM has been to map terrain features having similar terrain configuration, ecological properties and management implications within which situational landscape-ecosystems can logically and conveniently be defined (Anonymous 1994). Within the formal structure of the ECOMAP (1993) national hierarchy of ecological units, we have mapped Landtype Associations as representing a practical means for delineating landscapes, or at least portions of terrain that can be decomposed into smaller landscapes having highly similar properties such as topography, vegetation and soil patterns. This is a terrestrial-centered approach--dividing terrain into map units in terms of terrain features rather than by hydrological units. This philosophy is consistent with the approach recommended by Godfrey and Cleaves (1991) and ECOMAP, and in contradistinction with an alternative philosophy in which drainage basins are the defining landscape unit (Omernik and Bailey 1997, Lotspeich 1998).

In previous work (Reiners and Thurston 1994, 1995, 1996, 1997), we took a subjective approach to delineating Landtype Associations (LTAs) in Wyoming. By using a variety of coverages, including 3 arc second and 30 m resolution digital elevation model data, geology, landcover, among others, we interactively digitized Landtype Associations. As land form was our primary criterion, relief was usually the final determinant of where delineations were ultimately digitized. Thus, each boundary between LTAs and higher order units was based on subjective opinion applied by different criteria along the boundary line. This approach has been termed by Bailey (1996) the “method of controlling variables,“ meaning that different variables dictating local delineation were the most prominent in different parts of a map or even along a single boundary line.

While we were very confident of the reality of the units previously delineated, we became increasingly concerned over two issues: the subjectivity of the process and the extent of the units we delineated. Typically, our LTAs ranged from about 750 acres to over 1,240,00 acres in the southeast. This is larger than the 100 to 1000s of acres suggested by ECOMAP (1993) and in many cases, considerably larger than LTAs mapped within national forests adjacent to our map area. We expected that terrain units would have larger extents in basins compared with mountains because of the greater simplicity of underlying geology and the character of dominant geomorphological processes occurring in basins. On the other hand, we were not satisfied with our previous differentiation of land forms within these basins and looked for a means to better tease apart variations in roughness and form.

Others have used statistical methods to classify land forms, usually involving several variables (Bourgeron et al. 1994, Davis and Dozier 1990, Host et al. 1996, Mann and Benwell 1996, Capen et al. 1999). We believe that the different variables used in these systems vary at different scales and therefore are not likely to bound at the same places or to lead to definition of integral systems. For example, vegetation varies at a smaller scale than do the terrain features scaled to fit ECOMAP guidelines for LTA sizes, at least in the landscapes mapped in this project. Such multivariate classification approaches depend on the assumption that ecosystem properties are co-located in landscapes. We do not subscribe to that assumption. We contend that such methods probably tend to "smooth over" prominent, differentiating features in local cases. Incorporating multiple variables leads to compromises in polygon boundaries. It is possible that those overall products make general scientific sense, but we question whether resultant polygon boundaries make sense at local scales of approximately hundreds to thousands of meters. Making sense in local cases is extremely important to our and BLM's objectives. LTAs must be recognizable on the ground as well as on a map. In fact, in deciding whether geographic features should be mapped as an LTA, we asked ourselves the practical question:

> "would this feature be recognized by land users and managers in the field, and would they agree that it is sufficiently different from surrounding terrain that they would consider its management differently?"

This self-testing query forces us to see the landscape from the manager's or operator's points of view--on the ground. It also drives us toward use of terrain features as the primary determinant of LTAs. Terrain features may be based on underlying lithology or tectonics but more frequently they are products of fluvial geomorphological processes operating on the poorly consolidated materials filling Wyoming's basins and plains.

In this project, we sought an approach for delineating LTAs other than multivariate classification for reasons given above. We wished to reduce subjectivity and to better partition different land forms in what we had formerly combined together as "rolling plains" typical of Wyoming's basins. We sought to create smaller LTA units thereby creating a finer grain to the overall map. Terrain characterization systems exist, usually based on GIS processes (Fels and Matson 1996, Blaszczynski 1997, Medler and Yool 1998). We adopted an approach pioneered by Hammond (1964), who developed a map of "land-surface forms" of the United States from an empirical analysis of the land surface. Hammond (1964, 1970) used a selected group of surface characteristics as the basis of a simple classification scheme. Hammond's criteria for choosing these characteristics were that characteristics should:

> "1) be especially effective in conveying a visual image of surface form;
> 2) be broadly suggestive of possible relationships to other phenomena of geographical interest, especially potential land use;
> 3) be capable of being determined readily for broad areas from available map data, and
> 4) be capable of simple expression."

Hammond's characteristics included:

> "1) percent of area occupied by surfaces of gentle inclination (less than 8% or 4°35');

2) local relief, that is, maximum difference in elevation within a limited area, and;
3) percent of gently inclined surface that lies in the lower half of local relief."

We found Hammond's system fit our scale of landform resolution reasonably well, and still allowed us a degree of latitude for subjective interpretation that we still found desirable. We modified his approach as is described in Methods (Section 3).

2.2 Relationship to ECOMAP

As in past reports, the hierarchical system containing our delineated units follows the structure of the ECOMAP national hierarchy of ecological units (ECOMAP 1993). We have mapped Landtype Associations (LTAs) as well as higher hierarchical units in which LTAs are imbedded. LTAs are defined by ECOMAP (1993) as units at the "landscape scale" as follows:

> "groupings of Landtypes or subdivisions of Subsections based upon similarities in geomorphic process, geological rock types, soil complexes, stream types, lakes, wetlands, and series, subseries, or plant association vegetation communities. Repeatable patterns of soil complexes and plant communities are useful in delineating map units at this level. Names of Landtype Associations are often derived from geomorphic history and vegetation community."

In addition to mapping LTAs , we have also mapped higher hierarchical levels of the National Hierarchy of Ecological Units for the defined map area. In this process, we have defined land units up to four hierarchical levels above the LTA. These definitions of higher hierarchical units usually conform with the nationally accepted nomenclature, but often differ with respect to location. Our rationale for delineations of higher hierarchical units are given in section 4 of this report.

2.3 Potential Uses of this Product

While the principal objective of this work has been to produce a digital map of landscape-ecosystems for management purposes, the GIS coverages generated to do this, and provided along with the map as part of our deliverables, have a value in themselves. These coverages include information that can be used as decision support tools for regional planning and cumulative impact assessment. An array of accurate spatial data coverages can be used to provide distance, area, adjacency and proximity relations for features in a region of interest; GIS coverages can permit geographic analysis for queries and planning through joining and unioning coverages of thematic features for rapid assessment. For example, location of a facility with respect to bodies of water, geologic formations, or vegetation types can be done efficiently and accurately with GIS techniques. While we have not provided political boundary, road and other human-centered thematic data with this work, such data are readily available and can be added to the coverages delivered in this product to make queries and management decisions. For example, another data set that would be extremely valuable for land use managers would be the game range coverages undergoing refinement within the Wyoming Game and Fish Department.

The LTAs themselves have collective properties that are relevant to management decisions. Occurrences of a particular LTA should trigger an associated set of considerations appropriate to that LTA type. For example, LTAs in the glacial till and outwash hills class should signal consideration of swell and swale topography, scattered boulders, ice block ponds and wetlands. Alternatively, LTAs in the multiple cuesta and valley class signal the occurrence of linear, rocky outcrops interspersed with parallel valleys with deeper soils. In both cases, LTA class properties have relevance for managing wildlife, livestock and domestic or industrial development. Because LTAs have been mapped by consistent criteria across most of the state, understanding of one member of an LTA type can be transferred, with reparameterization, to another member of that type.

The hierarchical nature of this digital map product permits managers to scale up or down according to the scope of their concern. For example, managers may find that the Section or Subsection level of delineation is useful for strategic planning, whereas the LTA is most useful for evaluating specific projects.

Inasmuch as LTAs integrate basic environmental features (geology, geomorphology and geomorphic processes, soils, vegetation, wildlife, and habitats of rare and endangered species) in ways unique to that type of LTA, it may make sense for field data to be collected with respect to these map units, rather than by more artificial map units such as counties. For example, changes in management practices or aspects of the environment may produce trends in ecological properties that are characteristic of LTAs rather than politically or administratively defined units.

Managers are highly preoccupied with making judgments about resource use in the contemporary situation. In some cases, it may become mandatory to consider management tactics and rules in the context of possible climate change (e.g. Changnon and Demissie 1996). This certainly is the case for national park managers. The LTAs should be very valuable units for considering the implications of such changes.

In order for managers to make full use of LTA delineations, it will be necessary for them to understand what particular classes of LTAs represent in terms of patterns of environmental attributes, or simply the presence or absence of attributes. Delineating the LTAs will not be sufficient in itself. Much analysis of LTA types is needed to create an atlas of properties, both qualitative and quantitative.

2.4 Descriptions of Classes of Landtype Associations

In this and previous mapping projects for the BLM (Reiners and Thurston 1994, 1995, 1996, 1997), we have created a set of Landtype Association classes based as nearly as possible on geomorphic properties. Similarly, we have attempted to use names for these classes that match proper geomorphological terminology. The following are brief descriptions of the LTAs mapped in this work. Those LTAs that are based strictly on properties of slope and relief include the Hammond classification code in parentheses next to the LTA name.

Granite hills: A feature having mountain properties (according to Fairbridge (1968), a mountain is "a natural elevation of the earth surface rising more or less abruptly from the surrounding level, and attaining an altitude which, relatively to adjacent elevation, is impressive or notable") but of lesser relative relief (< 700 m) composed of crystalline metamorphic or magmatic rock. Some geomorphologists might describe these interesting hills as "bornhardts" (Fairbridge 1968).

Footslope: Many, but not all mountains have steep, upper slopes composed of bedrock above lower, less steep slopes of either weaker rocks, pediments or fans. Typically, there is a distinct break in slope between the steep upper portion and the less steep lower portion. Often the lower slope cantilevers gently into plains or basins away from the mountain. While the upper break in slope is relatively easy to delineate, often the delineation of the lower boundary of the lower slope is arbitrary. Because the lithology, hydrology, slope stability, soils and vegetation are so different between the upper and lower slopes, we have recognized a class of Landtype Association we term the "footslope." We recognize that these "footslopes" may be classified as pediments, benches, straths and fans, but without stratigraphic data and without broader consensus of these land forms, we are using the generic term "footslope." Generally, the base of the footslope was delineated at roughly the 4° break in slope, and the delineation between mountain and footslope at the 10° break in slope.

Breaks: This term is common in the American west but we have been unable to find a technical definition. Based on terrain designated as "breaks" on Wyoming maps, it appears that "breaks" most commonly refer to easily erodible, more or less horizontally bedded sedimentary materials that are highly incised by deeply cut, dendritic channel systems. Breaks often have more or less flat interfluves cut by a dense network of rapidly eroding, mostly ephemeral channels. This type is most often found in poorly consolidated Tertiary materials in the vicinities of rivers where base leveling is most advanced.

Mesa(s): ". . . flat-topped hills and mountains, cut off on one or more sides by steep escarpments or "breakaways" (Fairbridge 1968). Mesas mapped in this work are of "hill" proportions. In a classification based strictly on slope and relief, mesas would be divided into a flat plain surrounded by a steep escarpment. These two slope features are grouped together here to form a recognized landform.

Recessional escarpment: Steep, erosion fronts, often relatively linear in plan view, on poorly consolidated, sedimentary materials. Recessional escarpments often form prominent "rims"--distinct boundaries occurring between lowlands excavated by tributary networks of major rivers and high, often flat or gently rolling uplands relatively untouched by the stream grade of the adjacent lowland. Headward erosion along the escarpment face is typically rapid and may be accompanied by badlands landforms.

Multiple cuesta and valley complex: As a complex, this is our own term. We refer here to a series of long narrow, more or less parallel ridges separated by valleys as wide or wider than the ridges. Generally, these ridges and valleys are composed of dipping alternating beds of relatively harder or softer rocks, respectively. Technically, if the ridges are steeper than 40-45°, they are termed "hogbacks;" ridges dipping from 5-40° are sometimes called homoclinal ridges (Fairbridge 1968). We use the less-well defined term "cuesta" for both types of ridges in this report.

Single cuesta: A single long, narrow ridge, either a hogback or monoclinal ridge (see above). Single cuestas often have interrupted, stairstep form to the strike slopes but are separated from multiple cuesta valleys by the absence of valleys between the resistant layers.

Glacial till and outwash hills: Low hills and dissected fans associated with terminal moraines and outwash adjacent to mountains. Drainage on these hills is often immature and the terrain can be dotted with wetlands, ponds and lakes. These are determined by the presence of glacial deposits on the bedrock geology coverage.

Low mountains (D5): Less than 20 percent of the area has a slope of less than 5% and the local relief is between 1000 and 3000 feet. This is a more specifically defined form of a "hill" as defined by Fairbridge (1968) as under "mountains" above.

High hills (D4): Less than 20 percent of the area has a slope of less than 5% and the local relief is between 500 and 1000 feet.

Hills (D3): Less than 20 percent of the area has a slope of less than 5% and the local relief is between 300 and 500 feet.

Low hills (D2): Less than 20 percent of the area has a slope of less than 5% and the local relief is between 100 and 300 feet.

Open high hills (C4): 20 to 50 percent of the area has a slope of less than 5% and the local relief is between 500 and 1000 feet.

Open hills (C3): 20 to 50 percent of the area has a slope of less than 5% and the local relief is between 300 and 500 feet.

Open low hills (C2): 20 to 50 percent of the area has a slope of less than 5% and the local relief is between 100 and 300 feet.

Irregular plains with hills (B3): 50 to 80% of the area has a slope of less than 5% and the local relief is between 300 and 500 feet.

Irregular plains (B2): 50 to 80% of the area has a slope of less than 5% and the local relief is between 100 and 300 feet.

Plains with hills (A3): More than 80% of the area has a slope of less than 5% and the local relief is between 300 and 500 feet.

Smooth plains (A2): More than 80% of the area has a slope of less than 5% and the local relief is between 100 and 300 feet.

Flat plains (A1): More than 80% of the area has a slope of less than 5% and the local relief is less than 100 feet.

Alluvial valley: These are river valleys containing a third order stream or higher and also contain mapped alluvium.

River valley: These are valleys with a distinct river channel, with a third order stream or higher, but do not contain mapped alluvium.

Arroyo/draw: These concave features are deeply incised drainage channels similar to those described under "breaks" but more or less isolated in their occurance on flat or rolling terrain. These are similar to "gullies" as described by Fairbridge (1968) but are not necessarily products of human influence or climate change.

Lake/reservoir: Lakes are bodies of water confined in basins that are or were natural but may today be regulated by dams and flumes. Reservoirs are bodies of water formed by damming naturally occurring running waters--rivers and streams.

In addition to our Landtype Association coverages, we are also providing coverages for the Bridger-Teton, Shoshone, and Bighorn National Forests. All three National Forests have used different criteria for mapping Landtype Associations, so we have not attempted to edge match across National Forest Boundaries. National Forest LTAs are shown in Figure 32, Figure 33 and Figure 34. Landtype Association types are explained in Tables 8, 9, and 10 of the Appendix.

3. METHODS

3.1 Data used to Delineate Map Units

We created the following GIS layers in Arc/Info format for northwest Wyoming and the Buffalo Resource Area:

1) Thematic Mapper data subsampled at 100 m pixel resolution derived from the Wyoming Gap Analysis Project (Merrill et al. 1996, Driese et al. 1997).

2) Geology based on a state-wide digital product from the US Geological Survey (Green and Drouillard 1994) based, in turn, on Love and Christiansen (1985).

3) Digital elevation model (DEM) data in 30 m resolutions from US Geological Survey (1987). These data were resampled to a 60 m cell size. Several sets of data were derived from this coverage, including shaded relief, 50 m elevation intervals (from the 30 m DEM), slope, and slope and relief classification coverages. The latter two coverages are described in more detail below.

4) Mean annual precipitation data generated using algorithms developed by Daly et al. (1994) were prepared as contours of equal precipitation. The original data were raster data with a cell size of about 5 km.

5) Land cover (mostly vegetation types) based on the Wyoming Gap Analysis Project (Driese et al. 1997).

6) Digital soils map of Wyoming at a 1:500,000-scale (Munn and Arneson, 1998).

7) Surficial geology map of Wyoming at a 1:500,000-scale (Case et al. 1998).

8) Hydrologic unit delineations based on a 1:500,000 map produced by the US Geological Survey (1976).

9) Hydrography digital line graphs (DLG) from the US Geological Survey (1989).

3.2 Adaptation of Hammond System

Although the above coverages were all used interactively to identify LTAs, polygons were delineated primarily using a classification system of slope and relief based on the concepts of Hammond (1964). This required production of slope and relief coverages from 60 m DEM layers. The slope coverage consists of a neighborhood slope value for every 60 m cell. The neighborhood was defined by a circular window 13 DEM cells in radius for a total area of 1,911 ha. The window was positioned over every cell in the 60 m DEM coverage and the percent of area in the window having a slope of 5% or less calculated--the slope value for each cell. The resulting continuous slope values were broken into four slope classes as defined inTable 1.

Table 1. Slope classification based on Hammond (1964).

Slope Class	
A	More than 80 % of area is gently sloping
B	50 - 80 % of area is gently sloping
C	20 - 50 % of area is gently sloping
D	Less than 20 % of area is gently sloping

Note: "Gently sloping" is defined as a slope of 5 % or less.

The relief classification was created by calculating the maximum and minimum elevation changes occurring in the neighborhood surrounding the each cell using the Arc/Info Grid function FOCALRANGE. Continuous values for relief were divided into 6 relief classes as shown in Table 2.

Table 2. Classes of local relief based on Hammond (1964).

Relief Class	
1	0 - 100 feet
2	100 - 300 feet
3	300 - 500 feet
4	500 - 1000 feet
5	1000 - 3000 feet
6	over 3000 feet

The choice of 60 m DEM resolution and the size of the circular neighborhood window were based upon a series of trials. The neighborhood extent chosen seemed to afford optimal compromises between representing the grain of the terrain in most of the classified area, and data management efficiency.

Our methods involved several modifications of Hammond's (1964) original method. He used a unit area of 6 square miles to classify land-surface forms, and a minimum mapping unit of 800 square miles. We reduced the window size, or neighborhood, to 13 cells, or approximately 1,911 ha and the minimum mapping unit from 800 mi^2 to 500 ha (1.9 mi^2) to fit the finer mapping scale we desired for the terrain in question. Furthermore, we redefined "gentle inclination" as 5% instead of 8%, as we thought this better discriminated sub-elements of the rolling plains landscapes characteristic of the basins we mapped. Finally, we chose not to use Hammond's third criteria (the percent of gently inclined surface in the lower half of relief), as this characteristic was used to define "tablelands" and "canyonlands." Because of our smaller neighborhood, hills and canyons were delineated as individual Landtype Associations, rather than being included in broad areas that had hills (tablelands) or canyons (canyonlands).

The overlay of slope and relief produced clusters of cells having similar combinations of these properties. The outlines of these clusters were digitized by hand, taking into account other coverages (shaded relief, hydrology and geology). It was at this point that we switched from a wholly objective method to a subjective one by making decisions leading to the exact boundaries of units delineated primarily by the Hammond criteria. Additionally, several important Landtype Associations that might have been split into multiple polygons using the Hammond classification were identified and digitized. These included multiple cuesta valley complexes and mesas, both of which tended to be broken into slope and plain components using the Hammond classification. Also included were glacial till and outwash hills and alluvial valleys, both of which were defined by their geological components.

3.3 Classification of Polygons

After digitizing all LTA polygons, they were then classified using the modified Hammond criteria listed in Tables 1 and 2. Slope classification was done using a circular neighborhood of 3 cells rather than the 13-cell neighborhood used to guide the digitizing. This classification gave better resolution for flat polygons that were bordered by steeply sloping terrain, such as lakes. LTA codes were then assigned to each polygon. Many of these codes are based strictly on the slope and relief classification as prescribed by Hammond. However, some polygons were assigned to other LTA classes defined by recognizable features or other properties such as geology or presence of 3rd order or higher streams (see section 3.2).

For this report, our minimum mapping unit (MMU) guideline was 500 hectares (1,236 acres). Because we were constrained by adjacent US Forest Service boundaries and previous mapping (we maintained Scoria polygons, for example, in the Buffalo Resource Area), we mapped some Landtype Associations that were significantly smaller than our MMU. LTA polygons ranged from about 4.8 ha (12 acres) to over 226,316 ha (559,000 acres). Smaller polygons almost always occurred along the margins of the map areas, often where division, province, section or subsection boundaries intersected USFS boundaries. The mean polygon area in the northwest Wyoming coverage is approximately 12,200 acres, and in the Buffalo Resource Area is 11,740 acres. In general, LTA polygons were considerably smaller than polygons delineated in previous reports. For example, the mean polygon area we delineated in the southeast was approximately 101,700 acres.

The classified LTA polygon coverage was finally intersected with the landcover, soils, geology, surficial geology, precipitation and elevation coverages, and individual polygons attributed according to the properties of each intersected coverage. The result of these efforts are the Landtype Association coverages in Arc/Info format described in section 5.2. In addition, the arcs of the Landtype Association coverage have been attributed to indicate the source data and digitizing criteria (see section 5.4) .

3.4 Interactions with BLM Personnel

This work benefited from numerous telephone and e-mail conversations with BLM personnel. In addition, individual meetings were held with BLM personnel on the following occasions.

21-23 October 1997 Rob Thurston and Bill Reiners attended an interagency workshop on ecological mapping held in Casper, WY. Reiners presented UW's approach to modeling to this group and Thurston interacted throughout the meeting on seeking a common basis for mapping criteria and scale.

27-29 January 1998 Rob Thurston and Bill Reiners attended the Interagency Ecological Mapping Meeting held in Cheyenne, WY. This was a follow-up meeting to the previous Casper meeting at which representatives from involved agencies including BLM presented their map products and discussed development of a common product.

15 September 1998 Bill Daniels and Jon Johnson met with Bill Reiners and Rob Thurston in Laramie to review the status of the project and developing map products.

21 May 1999 A meeting between Jon Johnson, Jeff Carroll, Ellen Axtmann and Bill Reiners was held at the Dept. of Botany in Laramie during which progress was demonstrated and

reviewed, changes in the product were described, and contract deliverables were defined. The outcome of this meeting is covered in a letter from Reiners to Johnson dated 27 May 1999.

4. LAND AREA DELINEATIONS: DOMAINS, DIVISIONS, PROVINCES, SECTIONS AND SUBSECTIONS

4.1 Overview

Section 4 of this report contains rationales and descriptions of delineated land units at hierarchical levels above the Landtype Association level. Because of the finer scale mapping used in this report relative to previous reports and the large number of Landtype Associations, individual Landtype Association polygons are not described. Table 1 and Table 2 of the Appendix list all Landtype Association types and aggregated areas of each organized according to an ECOMAP-type hierarchy.

4.2 Domains and Divisions

"Domain" is the highest hierarchical level in the US Forest Service Ecoregion system (Bailey 1995). The Dry Domain is characterized by potential evapotranspiration being greater than precipitation (Bailey 1995) and covers the entire state of Wyoming, although this condition does not prevail in parts of the mountains of the state. The Dry Domain is coded as "300" within this system so that all mapped units within Wyoming have a "3" as a prefix in their numerical notation. This hierarchical unit is important at the continental scale but is not relevant for purposes of ecosystem management in an area the size of Wyoming.

Within the "Dry Domain" of the US occur seven "Divisions," which are also defined primarily in terms of macroclimate. Three Divisions occur in this map area (Figure 24 and Figure 28):

a) Temperate Steppe,
b) Temperate Steppe Regime Mountains, and
c) Temperate Desert Divisions.

The Temperate Steppe Division (330) includes areas "with a semiarid continental climatic regime in which, despite maximum summer rainfall, evaporation usually exceeds precipitation" (Bailey 1995).

The Temperate Steppe Regime Mountains Division (M330) is characterized by the same macroclimate as the Temperate Steppe Division but having changes in temperature and precipitation with changes in elevation. This Division encompasses all the mountain systems of the current map area.

The Temperate Desert Division (340) is characterized as areas of low rainfall but strong contrasts in seasonal temperatures (Bailey 1995).

4.3 Provinces

The next lower hierarchical level in the Ecoregion system is the "Province" defined by somewhat more specified macroclimatic properties. Within the area of the current map work, the Province boundaries happen to coincide with Divisional boundaries (Figure 24 and Figure 28). Thus, Provinces are the same as Divisions within the map area presented here. The single Province occurring in the Temperate Steppe Division is the "Great Plains-Palouse Dry Steppe" (331). According to Bailey (1995), it is

> "characterized by rolling plains and tablelands of moderate relief . . . The annual temperature is 45°F (7°C) throughout most of the region, but can reach as high as 60°F (16°C) in the south. Winters are cold and dry and the summers are warm to hot . . . Precipitation ranges from 10 in (260 mm) in the north to more than 25 in (640 mm) in the south, with maximum rainfall in the summer." The prevailing vegetation, "steppe, sometimes called shortgrass prairie, is a formation class of short grasses usually bunched and sparsely distributed."

In the part of the Great Plains-Palouse Dry Steppe Province mapped in this map area, the dominant parent materials are weakly consolidated, Tertiary sediments (Lillegraven 1993) (Figure 5) although extensive beds of clinker (scoria) occur where coal bed fires have baked overlying materials into more indurated state. The predominating soils on unmodified Tertiary materials are Typic Torrifluvents, Typic Haplocambids, Ustic Haplargids, Ustic Haplocalcids and Aridic Haplustolls. In the clinker zones, soils are Typic Torriorthents and Rock Outcrop (Munn and Arenson 1998). Vegetative cover over this province is a complex mixture of mixed grass prairie interfingering with Wyoming big sagebrush. Some of the grassland is now in dryland agriculture. Particularly throughout the scoria-covered areas, ponderosa pine groves occur. For more details see Knight (1994) Merrill et al. (1996) and Driese et al. 1997.

The mapped boundary for this Province is set by the state borders with South Dakota and Nebraska to the east and Montana to the north, by the bases of the Black Hills, Laramie Range and Bighorn mountain systems, and by the irregular line marking the contact with the Intermountain Semidesert Province to the west (Figure 28). The rationale for the delineation between the plains and mountains is based on change in relief at the bases of the mountains. The rationale for the delineation between the Great Plains-Palouse Dry Steppe on the east and the Intermountain Semi-desert Province on the west was discussed in a previous report (Reiners and Thurston, 1997). A general geological discussion of this Province is provided by Osterkamp et al. (1987).

The sole Province within the Temperate Steppe Regime Mountains Division within this map area is the "Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province (M331)" (Figure 24 and Figure 28). This is an area of

> "rugged, glaciated mountains . . . with intermontane depressions ("parks") . . . Many high-elevation plateaus composed of dissected, horizontally layered rocks lie in Wyoming and Utah . . . The climate is a temperate semiarid steppe regime with average annual temperatures ranging from 35° to 45°F (2° to 7°C) in most of the region, but

> reaching 50°F in the lower valleys . . . Total precipitation is moderate, but greater than on the plains to the east and west. In the highest mountains, a considerable part of annual precipitation is snow, although permanent snowfields and glaciers cover only relatively small areas" The Province has a "pronounced vegetational zonation, controlled by a combination of altitude, latitude, direction of prevailing winds, and slope exposure." (Bailey 1995).

A general description of the geology and historical processes associated with this Province can be read in Madole et al. (1987).

With the exception of the Absaroka Range, the mountains in the map area are Laramide features (Brown 1993). Typically, these have arisen from deep-seated faulting and are cored by Precambrian rocks including granites, gneisses, other metamorphics, and limited areas of mafic outcrops. Small to extensive areas of Paleozoic sedimentary rock occur in our delineations of this Province. Among soils, Rock Outcrop is a common type in all of the mountains. Other soils of the Absaroka Range are mapped as Typic Cryorthents, Humic Dystrocryepts and Histic Cryaquepts. Other ranges in this province also have Typic Haplocryalfs, Typic Dystrocryepts, Typic Haplocryolls, and Lithic Cryorthents (Munn and Arneson 1998). Vegetation varies with elevation and slope aspect, ranging from mixed shrubs and grasses in the low foothills, to lodgepole pine, spruce-fir and alpine vegetation with increasing elevation (Knight 1994).

The single Province occurring within the Temperate Desert Division within this map area is the "Intermountain Semi-desert Province (342)."

> "This Province covers the plains and tablelands of the Columbia-Snake River Plateaus and Wyoming basin . . . The Wyoming Basin consists of plains at elevations 6,000-8,000 ft (900 m) broken by isolated hills and low mountains . . . " Within the Wyoming Basin portion of this Province, "winters are cold, and summers are short and hot. Average annual temperatures range from 40° to 52°F (4° to 11°C) and the average growing season has fewer than 100 days in the south and 140 days in the north and east. Average annual precipitation ranges from 5 to 14 in (130 to 360 mm), and is fairly evenly distributed throughout the year . . . The chief vegetation, sometimes called sagebrush steppe, is made up of sagebrush or shadscale mixed with short grasses." (Bailey 1995).

In our map area, this Province has widely varying environments ranging from cool, moist mountains to rocky ridges to rolling plains, alluvial fans and playas. The small mountains in this Province are composed of Precambrian igneous and metamorphic rocks and Paleozoic sedimentary rocks. The ridge- and valley-forming rocks are usually Mesozoic sediments, mostly of Cretaceous age, and the plains are primarily composed of Cretaceous shales or poorly consolidated Tertiary sediments. Soils of the mountains are generally classified as Typic Hapludolls, Typic Hapludalfs and Rock outcrops. Soils of the cuestas are generally classified as Torriorthents. Dominant soils of the basins are Typic Haplargids, Typic Haplocalcids, Typic Natrargids (Munn and Arneson 1998). While the small mountains may be forested, mainly in lodgepole pine, the cuestas are often shrub-dominated as described by Knight (1994) for "escarpments and the foothill transition." The basins fall into his description of "sagebrush steppe" and "desert shrublands and playas." According to Merrill et al. (1996), dominant land cover types of the basins include greasewood, saltbush, mixed desert shrub, Wyoming big sagebrush with smaller amounts of black sagebrush and basin big sagebrush.

4.4 Sections and Subsections of the Great Plains-Palouse Dry Steppe Province

4.4.1 Northwestern Great Plains Section (331F)

The Northwestern Great Plains Section is described but not delineated in McNab and Avers (1994). They say:

> "This area includes gently sloping to rolling, moderately dissected shale plains. There are some steep, flat-topped buttes, particularly in eastern Wyoming . . . Precipitation ranges from 10 to 20 in (250 to 510 mm) with more than half falling during the growing season . . . Most of the Section has natural prairie vegetation, which includes western wheatgrass, green needlegrass, blue grama, needleandthread, and buffalograss."

Our delineation of this Section is given in Figure 29.

Descriptions of the Subsections of this Section have not been published although some tentative Subsection delineations have been made on a map distributed by Freeouf (1996). Our Subsections (Figure 30) do not fully conform to theirs in name or organization, and definitely not in location of the delineating boundaries. We have rejected recognition of Powder River Basin as a subsection (Freeouf 1996). We have found structural basins in the eastern third of the state to not have much topographic expression and therefore, not have much practical use for ecoregion delineation. This is particularly true of the Power River Basin which doesn't even have any hydrological control for this area. We recognize seven subsections in this entire section (Figure 30), three of which occur in this current mapping area.

In previous reports (Reiners and Thurston, 1994, 1995) we delineated Scoria Hills as a separate subsection. The Scoria Hills had been digitized from a map of scoria, or clinker, prepared by Mr. Ed Heffern (Heffern and Coates, 1997) but on the 30 M DEM it is clear that landscape features associated with mesas, scarps, talus slopes and fans go beyond the limit of the mapped scoria. Because the Hammond classification scheme we used did not conform readily to the previously mapped Scoria Hills, we have included Scoria or clinker as a polygon attribute for both the Upland Plains and Powder River Breaks Subsections as opposed to being a separate subsection in itself. Areas consisting of clinker have Typic Torriorthent and Rock Outcrop soils (Figure 9). Vegetation contains many of the same elements as for the other subsections but includes some xeric shrub (mainly mountain mahogany) and ponderosa pine (Figure 23).

4.4.1.1. Casper Arch Subsection (331Fa)

This Subsection is well delineated by a tectonic feature known geologically as the Casper Arch (Figure 30). This is a Laramide rise or anticline extending broadly from the northern end of the Laramie Range northwestward to the southeastern corner of the Bighorn Mountains (Figure 5), or alternatively, as a "sag" between the Laramie Range and Bighorn Mountains

(Lageson and Spearing 1988). The northeastern and southwestern borders of this arch are bounded by deformed Cretaceous formations exposed at the surface as low to medium dip homoclinal ridges. Within the Arch occur some younger cuestas but much of the interior is occupied by a soft shale which has been eroded into gently rolling plains except for some incipient "breaks" near the rivers. Major soils of the eastern part of this subsection are Typic Torrifluvents, Typic Haplocambids, Ustic Haplargids, Ustic Haplocalcids and Aridic Haplostolls; soils of the western part of the subsection are Typic Hapludolls and Typic Hapludalfs (Figure 9). Primary vegetation throughout the subsection is a coarse-grained mixture Wyoming big sagebrush and mixed grass prairie, the type depending mainly on parent material.

4.4.1.2 Powder River Breaks Subsection (331Fh)

Although we previously delineated this area as a section (Reiners and Thurston, 1995), as does Freeouf (1996), we are delineating it in this report as a subsection because of its essential similarity with adjacent parts of the Upland Plains Subsection. This is a discreet area of intense, fine-grained dissection in the center of the gently sloping Powder River Basin. The high degree of dissection is made possible by erosion of the poorly consolidated Wasatch Fm. and a much smaller area of Ft. Union Fm. by the Powder River and its tributaries. This subsection includes areas that were previously designated as Scoria Subsection. Regionally dominant soils are shallow Torriorthents on the uplands and steep side-slopes and include Torrifluvents, Haplargids and Torriorthents in the flood plains (Figure 9). Vegetation is primarily Wyoming big sagebrush steppe and mixed grass prairie on the undissected interfluves and slopes running down to the incised ravines. Vegetation is scant on the steep, eroding walls, but relatively luxuriant deciduous riparian vegetation and agricultural cover types occur on the fans at the mouths of the ravines and out the broader floodplain terraces (Figure 23). This section includes scoria features as noted above.

4.4.1.3 Upland Plains Subsection (331Fy)

This subsection is bounded by the Casper Arch subsection to the southwest, the Bighorn Mountains to the northwest, the Black Hills to the northeast, and the North Platte River-Niobrara River subsection to the south. It is the matrix within which the Powder River Breaks Subsection occurs. Within the map area, this subsection consists largely of various members of the Ft. Union Fm. and Wasatch Fm (Figure 5). With the exception of some resistant members of the Ft. Union Fm., these are mainly weakly to poorly indurated beds that are easily eroded. Since late Tertiary time, they have developed a gentle topographic form. The landscape mainly features broad interfluves separated by more active slopes closer to the tributaries of several rivers draining the area. Soils are the same as those described for the eastern portion of the Casper Arch Subsection (Figure 9). Vegetation consists of mixed grass prairie, Wyoming big sagebrush and dryland farmland (Figure 23).

4.5 Sections and Subsections of the Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province

4.5.1 Yellowstone Highlands Section (M331A)

The Yellowstone Highlands Section is described but not delineated in McNab and Avers (1994) as follows:

> "The Yellowstone Plateau was formed from two volcanic episodes. Other areas include high rugged mountains with ridges and cirques at higher elevations and narrow to broad valleys. Much of this area has been glaciated and moraines are common. Elevation ranges from 6,000 to 13,000 ft. (1,800 to 4,100m) in the mountains, and 2,500 to 6,500 ft. (763 to 1,983 m) in the basins and valleys... Precipitation ranges from 20 to 45 in (520 to 1,149 mm) annually; most occurs during fall, winter and spring... Temperature averages 35 to 47 ° F (2 to 8 ° C)... Lodgepole pine is the common cover type... Alpine vegetation, including whitebark pine and subalpine fir, occurs above 9,500 ft (2,878 m). Sheep fescue, alpine bluegrass, and American bistort are common grass and forb species."

Our subsectional delineations within this section follow Freeouf (1996) with modifications based on more detailed coverages available to us for relief and geology as noted in the subsection descriptions. We have delineated only 25 polygons within this section. Most of this section falls outside our map boundaries but is included in the Shoshone National Forest LTA coverage (Figure 25 and Figure 34).

4.5.1.1 Absaroka Range Subsection (M331Ad)

The eastern margin of this subsection was digitized along a slope contour of 10°. The demarcation between this subsection and the Owl Creek Mountains Subsection was drawn along the contact between the Absaroka Volcanic Supergroup to the north, and the Madison Limestone and Tensleep Formations of the Owl Creek Mountains. We mapped 12 polygons within this subsection. The rest of the subsection is included in the Shoshone National Forest LTA coverage (Figure 25 and Figure 34).

4.5.1.2 Beartooth Mountains Subsection (M331Ah)

Only the eastern-most margin of this subsection is included in our map area, consisting of one polygon with the Hammond designation of "high hills," indicating that less than 20% of the area is gently sloping (5% slope) and local relief is between 500 and 1000 ft (152 and 305 m). This subsection is delineated by Freeouf (1996), however we have redrawn the southwestern boundary to better coincide with the contact between the granitic gneiss of the Beartooth Mountains and the Absaroka Volcanic Supergroup to the west. We redrew the eastern boundary so as not to include alluvium and colluvium of the Bighorn Basin. The majority of this subsection is included in the Shoshone National Forest LTA coverage (Figure 25 and Figure 34).

4.5.1.3 Absaroka Sedimentary Mountains Subsection (M331Ai)

Only a small portion of this subsection is included in our map area, consisting of two polygons that both have a Hammond designation of "low mountains," indicating that less than

20% of the area is gently sloping (5% slope or less), and the local relief is 1000 to 3000 ft (305 to 914 m) . Although Freeouf (1996) delineates this subsection, our boundaries differ somewhat from his. The western boundary of this subsection coincides roughly with the volcanic/sedimentary contact, and the eastern margin follows the Cretaceous/Tertiary boundary west of Heart Mountain. The majority of this subsection is included in the Shoshone National Forest LTA coverage (Figure 25 and Figure 34).

4.5.1.4 Southern Absaroka Range Subsection (M331Aj)

Only seven polygons occur within this subsection in our map area. One polygon is classified as "low mountains," two are "high hills," two are "hills," one is "open low hills," and one is "irregular plains with hills." The boundary between this subsection and the Absaroka Range Subsection to the east follows the hydrologic unit boundary. To the south, this subsection is delineated along the southern extent of the Absaroka Volcanic Supergroup, and then follows a large nw-se-trending thrust fault that separates the Wind River formation of the Western Wind River Basin Subsection to the south from the Absaroka Mountains to the north. The majority of this subsection is included in the Shoshone National Forest LTA coverage (Figure 25 and Figure 34).

4.5.2 Bighorn Mountains Section (M331B)

This mountainous Section is quite distinct and recognized by Bailey (1996) and described by McNab and Avers (1994). McNab and Avers (1994) describes it as follows:

> "These are high mountains with sharp crests, rolling uplands, and dissected hills, with alpine glaciation dominating the upper third of the area. The rugged hills and mountains are cut by many narrow valleys with steep gradients. Elevation ranges from 4,000 to 13,000 ft (1,220 to 3,962 m)... Precipitation ranges from 15 to 40 in (380 to 1,020 mm), with much occurring as spring and fall rains... Temperature averages 36 to 43 ° F (2 to 6 ° C)... Common tree species include lodgepole pine, Douglas fir, subalpine fir, and Engleman spruce. Idaho fescue, bluebunch wheatgrass, and mountain big sagebrush are common grass and shrub species."

Our subsectional delineations within this section follow those of Freeouf (1996) with modifications based on more detailed coverages available to us for relief and geology as noted in the subsection descriptions.

The Hammond classification scheme used to delineate Landtype Associations does not discriminate well in steep terrain. The Landscape Associations in this section are largely delineated as "low mountains" and "high hills."

4.5.2.1 Bighorn Mountains, Sedimentary Subsection (M331Ba)

Both the eastern and western margins of this subsection were digitized along a slope contour of roughly 10°. This subsection consists mainly of Mesozoic and Paleozoic limestone, dolomite and sandstone, although it include some plutonic rocks in the north, and gneissic rocks in the south (Figure 4 and Figure 5). Deep, steeply walled canyons cut through the dipping sedimentary rocks, particularly along the eastern flank. Rock Outcrop and Lithic Cryorthents are the most common soils (Figure 8 and Figure 9). Mixed grass prairie is mapped for much of this area although it has a distinct mountain meadow character associated with the higher elevations. Juniper woodland is found at lower elevations on rocky outcrops and Douglas-fir in the canyons (Figure 22 and Figure 23).

The majority of this subsection is included in the Bighorn National Forest LTA coverage (Figure 33). We have mapped 9 polygons in the northwest coverage within this subsection, seven of which are designated as "low mountains," one is "high hills," and one is "irregular plains."

4.5.2.2 Bighorn Mountains, Granitic/Gneiss Subsection (M331Bb)

This subsection is embedded within the Bighorn Mountains Sedimentary Subsection. Although it roughly follows the delineation of Freeouf (1996), our subsection boundary was digitized using both relief and geologic coverages and follows more closely the contact between gneissic and plutonic rocks with the surrounding sedimentary rocks. This area is generally higher and more rugged than the sedimentary subsection and soils consist primarily of Rock Outcrop and Lithic Cryorthents (Figure 8 and Figure 9). Vegetation includes bare rock, alpine tundra, lodgepole pine forest, spruce-fir forest, mountain big sagebrush, mountain meadow grassland and, along the lower margins, ponderosa pine woodland (Figure 22 and Figure 23).

The majority of this subsection is included in the Bighorn National Forest LTA coverage (Figure 33). We have mapped only 4 polygons in the Buffalo Resource Area within this subsection. Landtype Associations include "Footslope," "Low Hills," "High Hills," and "Low Mountains."

4.5.2.3 Owl Creek Mountains Subsection (M331Bc)

Our delineation of the boundary between the Owl Creek Mountains and Bighorn Mountains, Sedimentary Subsections roughly follows that of Freeouf (1996), however it is slightly to the east (Figure 26). Our line follows along Bridger Creek to the south, and Kirby Creek to the north. This line is roughly the topographic low dividing these two mountain ranges. This subsection bounds on the west with the Absaroka Range and Southern Absaroka Range Subsections, on the north with the Bighorn Basin and on the south with the Eastern and the Western Wind River Basin Subsections. The low range comprising this subsection is cored with Precambrian rocks in places but for the most part consists of Paleozoic sedimentary rocks dipping gently to the north (Figure 4). This is not a very high range and therefore is relatively dry throughout its elevational extent. Common soils are Typic Hapludolls and typic Hapludalfs on the sedimentary rocks with Rock Outcrop and Lithic Cryorothents on the Precambrian plutonic and metamorphic rocks (Figure 8). Vegetation is similar to that of the Bighorn Sedimentary Subsection.

This subsection is contained entirely within our northwest Wyoming map area. The majority of the subsection is mapped as "High Hills," although other Landtype Associations include "Low Hills," "Open Low Hills," "Hills," "Single Cuesta," "Alluvial Valley," and "River Valley."

4.5.3 Overthrust Mountains Section (M331D)

This section is described but not delineated by McNab and Avers (1994) as occurring in

> "part of western Wyoming, southeastern Idaho, and north-central Utah. Mountain ranges include the Tetons and Salt River Ranges in Wyoming... Anticlinal and synclinal structures and thrust fault zones control development of linear valleys and ridges in the northern part of this section... Precipitation ranges from 16 to 40 in (400 to 1,016 mm) annually; most occurs during fall, winter, and spring... Temperature averages 35 to 45°F (2 to 7°C)... Vegetation zones are controlled by a combination of altitude, latitude, slope exposure, and prevailing winds. Areas of alpine tundra exist on highest mountains, subalpine zone has spruce-fir forests, and montane zone has ponderosa pine and Douglas-fir forest. Sagebrush occurs at the lowest elevations."

The only subsection include in our map area is the Jackson Hole Subsection (M331Dc), and only a portion of it is included in our coverage. Freeouf (1996) includes the Gros Ventre Range in this section, although in a previous report Reiners and Thurston (1996) pointed out that the Gros Ventre is not an overthrust feature, but rather a Laramide feature (Royse 1993). For that reason we delineated a separate Section for the Gros Ventre Range (M331X)

4.5.3.1 Jackson Hole Subsection (M331Dc)

This subsection has been delineated by Freeouf (1996) but is misplaced in the Overthrust Mountains Section inasmuch as it is surrounded by the extension-faulted Teton Range to the west and Laramide structures overprinted with Eocene volcanics to the east (Royse 1993, Smith et al. 1993). Very simply, it is not part of the overthrust belt. Essentially this subsection is a long valley resulting in part from block subsidence along the Teton fault, in part with subsequent partial filling with Tertiary and Quaternary materials. Inasmuch as most of this is National Park Service property, we did very little mapping in this subsection and will not undertake the subsection's description.

In fulfillment with BLM task requirements, we only delineated terrain outside Federal land boundaries. LTAs delineated were mostly flat plain or high hills.

4.5.4 Wind River Range Section (M331J)

McNab and Avers (1994) describe this section as

> "high alpine mountains that have been glaciated. Glacial troughs, cirque headwalls, and floors are common. The highest areas have glaciers covering the mountain tops. Elevation ranges form 6,000 to 13,000 ft (1,800 to 4,100 m)... Precipitation ranges from 15 to 100 in (375 to 2,550 mm) annually, increasing with elevation. Most occurs during fall, winter and spring as snow... Temperature averages 34 to 47°F (2 to 8°C)...

vegetation types include lodgepole pine and alpine grasses and forbs. Areas of spruce-fir and Douglas-fir forest occur in this Section."

Among the five subsections within this section delineated by Freeouf (1996), only the two subsections included in our map area are described below. The majority of this section is included in the Bridger-Teton and Shoshone National Forests coverages (Figure 32 and 34).

4.5.4.1 Flat Irons Subsection (M331Jd)

This subsection, delineated by Freeouf (1996) includes most of the eastern margin of the Wind River Range. We have redrawn the boundaries slightly to coincide with the western margin of the contact between the Bighorn Dolomite of the Flat Irons Subsection and the gneissic and granitic rocks that constitute the core of the Wind River Range. The eastern margin is drawn at the base of mountain slope, roughly along the boundary between the Permian Phosphoria Formation of the Flat Iron Subsection and the lower Triassic Chugwater and Dinwoody Formations that form much of the Western Wind River Basin Subsection. The portion of this subsection included in our map area is classified as "low mountains" based on Hammond criteria.

As the name suggests, this subsection consists of a long line of steeply dipping Paleozoic sedimentary rocks cut through at intervals with deep, steep-walled canyons. In places, U-shaped glacial valleys penetrate the hogbacks composing this subsection. The geological formations are described above. Dominant soils include Lithic Cryorthents and Rock Outcrops at the upper elevations and Typic Hapludolls and Hapludalfs at lower elevations (Figure 8). Vegetation ranges from mixed grass prairie to mountain big sagebrush to lodgepole pine forest in order of increasing elevation (Figure 22).

4.5.4.2 Eastern Subsummit Surface Subsection (M331Je)

As the name implies, this subsection encompasses the eastern side of the gneissic and granitic core of the Wind River Mountains. Freeouf (1996) delineated this subsection although it is not clear, from an examination of relief (Figure 18) why it should be called a "subsummit surface." In spite of its name, this area is not noted for its concordant summit areas as is much more obvious on the western side of this range (Mears 1993). For this reason, we do not support this subsection name. Given that most of the LTA delineations have been mapped by the USFS, we do not suggest an alternative.

Although our map boundary extends up to the hydrologic divide, we have not demarcated the boundary between the Wind River Mountains Subsection and the Eastern Subsummit Subsection of Freeouf (1996).

The USFS mapped LTAs through most of this subsection. We have contributed LTA delineations in the portion held by the Wind River Indian Reservation. Most of subsection that we delineated is classified as Low Mountains.

4.6 Sections and Subsections of the Intermountain Semi-desert Province

4.6.1 Central Basin and Hills Section (342F)

The Central Basin and Hills Section is described but not delineated by McNab and Avers (1994) as

> "plains eroded to clay shale bedrock, creating badlands. Mountain ranges include steep slopes that rise sharply from desert basins. There are alluvial fans, piedmont plains, and piedmonts that slope from mountains to stream terraces of the Wind-Bighorn system, and to broad intermountain basins. Rugged hills and low mountains are cut by narrow valleys with steep gradients. Broad flood plains are associated with some of the major rivers . . . Precipitation ranges from 5 to 30 in (120 to 730 mm). Temperature averages 39 to 52°F (4 to 11°C). Vegetative communities range from grass to grass-shrub to shrub-grass to forest."

Among the nine subsections within this section delineated by Freeouf(1996), only the three listed below are included in our map area.

4.6.1.1 Granite Mountains Subsection (342Fa)

The Granite Mountains Subsection is a well-demarcated and physiographically unique land unit (Figure 26). It is an interesting Laramide feature in which deep-seated faulting brought Precambrian rocks above the surface, deforming overlying sedimentaries to the north (Rattlesnake Mountains) and south (Freezeout, Shirley, Seminoe, Ferris and Green Mountains) (Figure 4). Later, the interior portion of this Precambrian mass dropped back down again leaving behind the small bounding mountains to the north and south, and mere tips of granitic peaks scattered within a plain of recent sediments (Love 1970). The geology of the Seminoe, Shirley and Freezeout Mountains along the southern margin have been recently reinterpreted by Lillegraven and Snoke (1996).

We have delineated this Subsection to include the bounding mountains to the south, but not the north, and the plains and granite hills scattered throughout the plains (Figure 26). The northern boundary is set by a distinct recessional escarpment -- the Beaver Divide, also known as Beaver Rim (Figure 27). The sagebrush-covered plains are formed from fans and piedmonts extending from the bordering mountains, and old and current alluvial terraces associated with the ancestral drainages and the present-day Sweetwater River. The granite hills are highly weathered, exfoliating knobs of granite that are largely unvegetated. The soils covering the areas not occupied by granite hills include Ustic Haplargids, Typic and Ustic Natrargids and Typic Torriorthents. The granite hills themselves are mainly Rock Outcrop (Figure 8).

4.6.1.2 Eastern Wind River Basin Subsection (342Fg)

The Eastern Wind River Basin Subsection is an area of rolling plains that includes drainages leading into the Wind River system to the west (Figure 26). It is bound by the Bighorn Mountains to the north and mostly hydrologic unit boundaries to the east. It is separated from the Granite Mountains Subsection to the south by the Beaver Divide, We have attempted to delineate the boundary between the Eastern and Western Wind River Basins more precisely than Freeouf (1996) by following natural topographic features. Our division follows along the east side of Beaver Creek, north from the Beaver Divide, and then along the east side of the Wind River and Boyson Reservoir.

Two primary parent materials cover this subsection, Eocene sediments and Quaternary Sand (Figure 4). Relief is quite limited. Dominating soils are Ustic Haplargids and Natrargids with Typic Torrifluvents to the western portion of the subsection. Considerable area is covered by Torripsamments where dune fields occur (Figure 8). Vegetation cover is mainly Wyoming big sagebrush with salt desert shrub along the northern margin (Figure 22).

4.6.1.3 Western Wind River Basin Subsection (342Fh)

The Western Wind River Basin subsection is also an area of rolling plains, but includes distinct cuesta valley complexes along the eastern front of the Wind River Mountains and south of the Owl Creek Mountains. These cuesta valley complexes are formed by dipping beds of alternating relatively harder or softer rocks of Mesozoic age. This subsection is bounded to the north by the Owl Creek and Absaroka Ranges, and to the southeast by the Wind River Mountains.

Geological parent material for this area is mostly poorly consolidated Eocene sediments with extensive areas of Quaternary Terrace and Alluvium in association with the Wind River itself (Figure 4). Some mostly consolidated sand fields and dunes also occur. The dune fields are dominated with Typic Torripsamments; the Tertiary materials are dominated by Ustic Haplargids and Typic Torrifluvents; and alluvium is dominated by Ustic Haplocambids and Ustic Haplargids (Figure 8). Except for irrigated agriculture on alluvial terraces surrounding most of the larger streams, vegetation covering most of the subsection is classified as Wyoming big sagebrush with some salt desert shrub (Figure 22).

4.6.2 Bighorn Basin Section (342A)

This section is described but not delineated by McNab and Avers (1994). They say:

> "There are piedmont plains and mountain footslopes with large stream terraces along the Wind-Bighorn River system. Plains are eroded to clay shale bedrock in some places, forming badlands. Elevation ranges from 3,600 to 5,900 ft (1,100 to 1,800 m)... Precipitation averages 5 to 9 in (120 to 230 mm). Temperature averages 45 ° F (7 ° C)... Küchler classified potential vegetation as saltbush-greasewood, wheatgrass-needlegrass-shrubsteppe, and sagebrush steppe. Common species include big sagebrush, gardner saltbush, indian ricegrass, and needleandthread. Black sage and bluebunch wheatgrass are common on areas of shallow soils."

The Bighorn Basin Section is almost entirely included within our northwest Wyoming map area. Our subsectional delineations within this section roughly follow those of Freeouf

(1996) with modifications based on more detailed coverages available to us for relief and geology as noted in the subsection descriptions. Freeouf (1996) delineated a subsection called The Northern Rocky Mountain Foothills, however we have eliminated this subsection in our map as there seems to be no geologic or topographic justification for this it.

4.6.2.1 Bighorn Basin Subsection (342Ad)

This is the only subsection that we delineate within the Bighorn Basin Section. This is a very large subsection by ECOMAP standards but it is marked by considerable uniformity. Almost the entire margin is characterized by Permian, Jurassic and Cretaceous beds gently dipping away from the Absaroka Mountains to the west, the Bighorn Mountains to the east, and the Owl Creek-Bridger Mountains to the south. These may be continuous ridges forming cuesta-valley complexes, or may be isolated hills with dipping, planar surfaces where streams crossing the cuestas from above have segmented the ridges. Within this Permian-Mesozoic margin area is a very large central zone dominated by early Tertiary sediments having little induration. Superimposed on the Tertiary zone are extensive areas of Quaternary Terrace and some Alluvium bordering the several major streams entering the basin from the mountains all around it (Figure 4).

Soils of the Permian-Mesozoic margin are typically Typic Hapludolls and Typic Hapludalfs; soils of the central Tertiary beds are typically Typic Torriorthents, Rock Outcrop, Typic Haplargids and Typic Natrargids; soils of the terraces and alluvium crossing the basin are typically Typic Torrifluvents and Typic Haplocambids (Figure 8). Vegetation ranges from juniper woodland on the rockier margins to Wyoming big sagebrush on the coarser textured materials of the central area to very extensive areas of saltbush on finer textured shales (Figure 22).

5. DETAILS OF THE LANDTYPE ASSOCIATION COVERAGES

5.1 General Information

Northwest Wyoming and Buffalo Resource Area coverage descriptions:

These Landtype Association coverages map northwest Wyoming and the Buffalo Resource Area at the Landtype Association level of the ECOMAP hierarchy. The Landtype Associations are represented by single and multiple polygons. The polygons and lines are attributed so that any level of the hierarchy can be selected. The lines are also attributed to indicate the source GIS layer or background display for on-screen digitizing and the criteria for the delineation.

Coverage name: ecounit_nw Date of last revision: 11 Dec 1999	Coverage size: 5446 kbytes
Coverage name: ecounit_ne Date of last revision: 11 Dec 1999	Coverage size: 3694 kbytes

5.2 Arc/Info Description

Northwest Coverage

```
                    Description of SINGLE precision coverage ecounit_nw

                                  FEATURE CLASSES

                                     Number of  Attribute    Spatial
Feature Class          Subclass      Features   data (bytes) Index?   Topology?
-------------          --------      ---------  ------------ -------  ---------
ARCS                                     3157       140
POLYGONS                                  893       250                 Yes
NODES                                    2308

                                 SECONDARY FEATURES

Tics                                     1195
Arc Segments                           212459
Polygon Labels                            892

                                    TOLERANCES

Fuzzy    =                4.000 V          Dangle   =                 100.000 V

                                 COVERAGE BOUNDARY

Xmin =                 24475.281          Xmax =                 330043.094
Ymin =               4680130.500          Ymax =                4992257.000

                                      STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                            COORDINATE SYSTEM DESCRIPTION

Projection                  UTM
Zone                         13
Datum                     NAD27
Units                    METERS            Spheroid                CLARKE1866
Parameters:
```

Buffalo Resource Area Coverage

```
                    Description of SINGLE precision coverage ecounit_ne

                                  FEATURE CLASSES

                                     Number of  Attribute    Spatial
Feature Class          Subclass      Features   data (bytes) Index?   Topology?
-------------          --------      ---------  ------------ -------  ---------
ARCS                                     1820       140
POLYGONS                                  562       250                 Yes
NODES                                    1280
```

```
                          SECONDARY FEATURES

Tics                                         209
Arc Segments                              151057
Polygon Labels                               561

                              TOLERANCES

Fuzzy    =                 4.000 V         Dangle   =                100.000 V

                           COVERAGE BOUNDARY

Xmin =               292800.375            Xmax =                494118.250
Ymin =              4815880.000            Ymax =               4986157.500

                                 STATUS

The coverage has not been Edited since the last BUILD or CLEAN.

                      COORDINATE SYSTEM DESCRIPTION

Projection                    UTM
Zone                           13
Datum                       NAD27
Units                      METERS          Spheroid              CLARKE1866
Parameters:
```

5.3 Polygon Attributes

5.3.1 Items

(these are the same for both coverages)

```
COLUMN   ITEM NAME       WIDTH OUTPUT  TYPE N.DEC  ALTERNATE NAME     INDEXED?
    1  AREA                  4    12    F     3                       -
    5  PERIMETER             4    12    F     3                       -
    9  ECOUNIT_NE#           4     5    B     -                       -
   13  ECOUNIT_NE-ID         4     5    B     -                       -
   17  MCODE                 1     1    C     -                       -
   18  PCODE                 3     3    I     -                       -
   21  SCODE                 1     1    C     -                       -
   22  SSCODE                2     2    C     -                       -
   24  LTACODE               2     2    I     -                       -
   26  LTANAME              80    80    C     -                       -
  106  SLOPE                 4     8    B     -                       -
  110  RELIEF                4     8    B     -                       -
  114  HAMMOND_CLASS         3     3    I     -                       -
  117  HAMMOND_CODE          3     3    C     -                       -
  120  SCORIA                2     2    I     -                       -
  122  MEANELEV              4     8    B     -                       -
  126  MEANPPT               4     8    B     -                       -
  130  PRIMBED               5     5    C     -                       -
  135  PRIMBED_AREA          4    12    F     3                       -
  139  SECBED                5     5    C     -                       -
  144  SECBED_AREA           4    12    F     3                       -
  148  TERTBED               5     5    C     -                       -
  153  TERTBED_AREA          4    12    F     3                       -
  157  PRIMSURF             10    10    C     -                       -
  167  PRIMSURF_AREA         4    12    F     3                       -
  171  SECSURF              10    10    C     -                       -
```

```
181  SECSURF_AREA          4    12     F     3                        -
185  TERTSURF             10    10     C     -                        -
195  TERTSURF_AREA         4    12     F     3                        -
199  PRIMSOIL              4     4     C     -                        -
203  PRIMSOIL_AREA         4    12     F     3                        -
207  SECSOIL               4     4     C     -                        -
211  SECSOIL_AREA          4    12     F     3                        -
215  TERTSOIL              4     4     C     -                        -
219  TERTSOIL_AREA         4    12     F     3                        -
223  PRIMVEG               5     5     I     -                        -
228  PRIMVEG_AREA          4    12     F     3                        -
232  SECVEG                5     5     I     -                        -
237  SECVEG_AREA           4    12     F     3                        -
241  TERTVEG               5     5     I     -                        -
246  TERTVEG_AREA          4    12     F     3                        -
   **  REDEFINED ITEMS  **
 17  LUCODE                9    10     C     -                        -
```

5.3.2 Item Definitions

ECOUNIT_NW-ID (or ECOUNIT_NE-ID) This field contains the user-assigned polygon ID. Each polygon has a unique six digit number, the first two digits of which are equal to the two-digit Landtype Association code (LTACODE). Figure 27 and Figure 31 show the polygons of the Landtype Association coverages for northwest Wyoming and the Buffalo Resource Area shaded according to LTA type.

MCODE This field is either blank or contains an M to indicate mountains.

PCODE This field contains a three digit code to indicate the province.

SCODE This field contains a single uppercase letter (A, B, C, . . .) to indicate the section.

SSCODE This field contains a single lowercase letter to indicate the subsection.

LTACODE This field contains a two digit code to indicate the Landtype Association. The results of a frequency analysis on this item are presented in Table 3 and Table 4.

Code	Landtype Association
12	Low Hills
13	Hills
14	High Hills
15	Low Mountains
22	Granite Hills
26	Footslopes
35	Breaks
36	Mesa
41	Recessional Escarpment

51	Multiple Cuesta and Valley Complex
52	Single Cuesta
61	Glacial Till and Outwash Hills
62	Open Low Hills
63	Open Hills
64	Open High Hills
76	Flat Plains
77	Smooth Plains
79	Irregular Plains
83	Lake/Reservoir
84	Alluvial Valley
85	River Valley
86	Arroyo/Draw
91	Plains with Hills
92	Irregular Plains with Hills

Table 3. Frequency analysis of LTA types for the Buffalo Resource Area.

LTACODE	No. of Polygons	Hectares	Percent of Total
12	41	141,029	5.3
13	27	165,091	6.2
14	4	103,764	3.9
15	1	27,541	1.0
26	5	69,997	2.6
35	70	976,736	36.7
51	2	31,814	1.2
62	140	470,734	17.7
63	3	982	0.0
76	12	48,743	1.8
77	74	133,320	5.0
79	91	396,529	14.9
83	1	823	0.0
84	72	84,179	3.2
85	17	12,987	0.5
91	1	399	0.0
Totals	866	2,664,667	100.0

Table 4. Frequency analysis of LTA types for northwest Wyoming.

LTACODE	No. of Polygons	Hectares	Percent of Total
12	49	218,956	5.0
13	101	410,012	9.3
14	48	746,266	16.9
15	27	243,111	5.5
22	10	18,768	0.4
26	19	154,355	3.5
36	14	78358	1.8
41	22	62,460	1.4
51	19	107,030	2.4
52	15	39,961	0.9
61	10	20,709	0.5
62	167	837,191	19.0
63	8	11,082	0.3
64	1	586	0.0
76	30	155,765	3.5
77	116	333,551	7.6
79	149	636,172	14.4
83	6	17,408	0.4
84	69	287,343	6.5
85	9	28,032	0.6
86	1	2,178	0.0
91	1	211	0.0
92	2	1,822	0.0
Totals	**893**	**4,411,326**	**100.0**

LTANAME This field contains the name of the individual Landtype Association if one has been given.

SLOPE This field contains a 1-digit code based on a 4-part classification that indicates the percent of area has a slope of < 5% (see Table 1).

RELIEF This field contains a 1-digit code based on a 6-part classification of local relief (Table 2).

HAMMOND_CLASS This field contains a 2-digit code. The first digit indicates the slope class and the second digit indicates the local relief class (see above).

HAMMOND_CODE This field contains a 2-character code equivalent to HAMMOND_CLASS. The first character indicates the slope class (where A is equivalent to 1 in the HAMMOND_CLASS attribute, B = 2, C= 3, and D= 4), and the second character is identical to the second digit in the HAMMOND_CLASS attribute.

SCORIA	This field contains either a 0, 1, or 2, and indicates the absence of scoria, presence of scattered scoria, or presence of extensive scoria according to data provided by Mr. Ed Heffern, BLM.
MEANELEV	This field shows mean elevation for each polygon in meters. Data were derived from the 60m DEM.
MEANPPT	This field shows mean annual precipitation (mm) calculated using data obtained from Daly et al. (1994) with a cell size of 5 km.
PRIMBED	This is a 5-character code indicating the most common geologic unit in each polygon. These data were obtained by intersecting the Landtype Association coverage with the bedrock geology coverage (US Geological Survey, 1994). The three most common types are listed as attributes in the Landtype Association coverage as seen below. Geology codes are explained in Table 4 of the Appendix.
PRIMEBED_AREA	This field shows the area of the polygon covered by PRIMBED in km^2.
SECBED	Thus is a 5-character code indicating the second most common geologic unit in each polygon.
SECBED_AREA	This field shows the area of the polygon covered by SECBED in km^2.
TERTBED	Thus is a 5-character code indicating the third most common geologic unit in each polygon.
TERTBED_AREA	This field shows the area of the polygon covered by TERTBED in km^2.
PRIMSURF	This field shows the most common surficial geology unit in each polygon. These data were obtained by intersecting the Landtype Association coverage with the surficial geology coverage (Case et al, 1998). Surficial geology single-element codes are explained in Table 6 of the Appendix. Single element codes were combined into a multi-element classification for a specific mapping unit. In many cases, a specific mapping unit may be composed of many single elements, such as slopewash (s), colluvium (c), and bedrock (R), that in certain areas can not be shown separately at scales of 1:100,000 or 1:500,000. In such cases, the single elements were combined into a more complex unit (scR), with the single elements ranked from most dominant to least dominant. The mapping unit scR would then represent a complex deposit composed of slopewash, colluvium, and bedrock outcrops, with more slopewash present than either colluvium or bedrock outcrop.
PRIMSURF_AREA	This field shows the area of the polygon covered by PRIMSURF in km^2.
SECSURF	This field shows the second most common surficial geology unit (reclassified) in each polygon.

SECSURF_AREA	This field shows the area of the polygon covered by SECSURF in km^2.
TERTSURF	This field shows the third most common surficial geology unit (reclassified) in each polygon.
TERTSURF_AREA	This field shows the area of the polygon covered by TERTSURF in km^2.
PRIMSOILS	This field shows the most common soil type in each polygon. These data were obtained by intersecting the Landtype Association coverage with the soils coverage (Munn and Arneson, 1998). Soil unit codes are explained in Table 7 of the Appendix.
PRIMSOILS_AREA	This field shows the area of the polygon covered by PRIMSOILS in km^2.
SECSOILS	This field lists the second most common soil type.
SECSOILS_AREA	This field shows the area of the polygon covered by SECSOILS in km^2.
TERTSOILS	This field lists the third most common soil type.
TERTSOILS_AREA	This field shows the area of the polygon covered by TERTSOILS in km^2.
PRIMVEG	This field contains a 4-digit code that indicates the most common primary landcover type present in the polygon. These data were obtained by intersecting the Landtype Association coverage with the landcover coverage (Driese et al. 1997). Landcover types are provided in Table 3 of the Appendix.
PRIMVEG_AREA	This field lists the area of the polygon covered by PRIMVEG in km^2.
SECVEG	This field lists the second most common primary landcover type.
SECVEG_AREA	This field lists the area of the polygon covered by SECVEG in km^2.
TERTVEG	This field lists the third most common primary landcover type.
TERTVEG_AREA	This field lists the area of the polygon covered by TERTVEG in km^2.
LUCODE	This redefined item can be used to select specific polygons using the complete land unit code. Examples of land unit codes include ' 331Fy14' and 'M331Bb26'.

5.3.3 Sample Records from the Polygon Attribute Table

```
               20
AREA                        = 14169106.000
PERIMETER                   =    21829.729
ECOUNIT_NW#                 =    20
ECOUNIT_NW-ID               = 62004
MCODE                       =
PCODE                       = 342
SCODE                       = A
SSCODE                      = d
LTACODE                     = 62
LTANAME                     =
SLOPE                       =        3
RELIEF                      =        2
HAMMOND_CLASS               =  32
HAMMOND_CODE                = C2
SCORIA                      =  0
MEANELEV                    =     1564
MEANPPT                     =      309
PRIMBED                     = PM
PRIMBED_AREA                =       14.170
SECBED                      = 0
SECBED_AREA                 =        0.000
TERTBED                     = 0
TERTBED_AREA                =        0.000
PRIMSURF                    = rRs
PRIMSURF_AREA               =       12.604
SECSURF                     = scrR
SECSURF_AREA                =        1.565
TERTSURF                    = rm
TERTSURF_AREA               =        0.001
PRIMSOIL                    = WY42
PRIMSOIL_AREA               =       14.169
SECSOIL                     = 0
SECSOIL_AREA                =        0.000
TERTSOIL                    = 0
TERTSOIL_AREA               =        0.000
PRIMVEG                     = 32007
PRIMVEG_AREA                =       12.007
SECVEG                      = 42015
SECVEG_AREA                 =        2.162
TERTVEG                     =     0
TERTVEG_AREA                =        0.000
```

```
                    5
 AREA                          =  7090467.500
 PERIMETER                     =     14037.528
 ECOUNIT_NE#                   =      5
 ECOUNIT_NE-ID                 = 12001
 MCODE                         =
 PCODE                         = 331
 SCODE                         = F
 SSCODE                        = y
 LTACODE                       = 12
 LTANAME                       =
 SLOPE                         =          4
 RELIEF                        =          2
 HAMMOND_CLASS                 =  42
 HAMMOND_CODE                  = D2
 SCORIA                        =  1
 MEANELEV                      =       1214
 MEANPPT                       =          0
 PRIMBED                       = Tftr
 PRIMBED_AREA                  =          7.090
 SECBED                        = 0
 SECBED_AREA                   =          0.000
 TERTBED                       = 0
 TERTBED_AREA                  =          0.000
 PRIMSURF                      = rsRk
 PRIMSURF_AREA                 =          7.092
 SECSURF                       = 0
 SECSURF_AREA                  =          0.000
 TERTSURF                      = 0
 TERTSURF_AREA                 =          0.000
 PRIMSOIL                      = WY17
 PRIMSOIL_AREA                 =          7.092
 SECSOIL                       = 0
 SECSOIL_AREA                  =          0.000
 TERTSOIL                      = 0
 TERTSOIL_AREA                 =          0.000
 PRIMVEG                       = 31001
 PRIMVEG_AREA                  =          6.780
 SECVEG                        = 42010
 SECVEG_AREA                   =          0.302
 TERTVEG                       = 61001
 TERTVEG_AREA                  =          0.009
```

5.4 Line Attributes

5.4.1 Items

```
COLUMN   ITEM NAME          WIDTH OUTPUT  TYPE N.DEC  ALTERNATE NAME     INDEXED?
    1  FNODE#                   4      5     B     -                          -
    5  TNODE#                   4      5     B     -                          -
    9  LPOLY#                   4      5     B     -                          -
   13  RPOLY#                   4      5     B     -                          -
   17  LENGTH                   4     12     F     3                          -
   21  ECOUNIT_NW#              4      5     B     -                          -
   25  ECOUNIT_NW-ID            4      5     B     -                          -
   29  TYPE                     4      5     I     -                          -
   33  SOURCE                   4      5     I     -                          -
   37  NOTE                   100    100     C     -                          -
  137  DIGITIZER                3      4     C     -                          -
```

5.4.2 Item Definitions

ECOUNIT-ID This field contains a unique, user-assigned, four- or five-digit arc ID. The range of IDs used for each project follows.

Project	ID Range
1 (Buffalo Resource Area, 1994)	>= 1001 and < 2000
2 (northeast Wyoming)	>= 2001 and < 3000
3 (southwest Wyoming)	>= 3001 and < 4000
4 (southeast Wyoming)	>= 4001 and < 5000
5 (northwest Wyoming)	>= 5001 and < 9000
6 (Buffalo Resource Area, 1999)	>= 9001 and < 11,000

TYPE This field contains a one or two-digit code that indicates the line type.

Code	Line Type
2	Division
3	Province
4	Section
5	Subsection
6	Landtype Association
11	County Boundary
12	State Boundary
13	U. S. Forest Service Boundary

SOURCE This field contains a three-digit code that indicates the source GIS layer for the arc, the background display used for on-screen digitizing, or the source map for on-tablet digitizing. The results of a frequency analysis on this item are presented in Table 5 and Table 6.

Arcs copied directly from specified coverages

101	County boundaries
105	Hydrologic units
106	Geology
107	Hydrography

Arcs digitized on-screen with the specified background displays. Arcs have been manually smoothed.

202	Geology
204	Streams
205	30 m shaded relief
206	90 m shaded relief
207	30 m shaded relief with hatched geology following relief using geology as

	a guide
208	30 m shaded relief with hatched geology following geology primarily
209	90 m shaded relief with hatched geology following geology primarily
215	No background
216	100 m thematic mapper imagery (4,5,3 (RGB))
218	30 m shaded relief with elevation contour following relief using elevation as a guide
224	90 m shaded relief with streams
226	30 m shaded relief with slope contour at about 4° following relief using contour as a guide
227	30 m shaded relief guided by 60 m shaded relief calculated from 60 m DEM data reclassified into 50 m intervals
229	30 m shaded relief following relief guided by hatched geology and slope contour at about 4°
230	30 m shaded relief following relief guided by hatched geology and slope contour at about 10°
231	30 m shaded relief with slope contour at about 10° following relief using contour as a guide
232	60 m shaded relief with streams
233	60 m shaded relief following relief guided by hatched vegetation
234	60 m shaded relief following relief guided by hatched geology and slope contour at about 4°
235	60 m shaded relief following relief guided by hatched geology and slope contour at about 10°
236	60 m shaded relief following relief guided by slope contour at about 10°
237	60 m shaded relief following relief guided by 30 m shaded relief derived from 30 m DEM data reclassified into 50 m intervals
238	30 m shaded relief derived from 30 m DEM data reclassified into 50 m intervals
239	60 m shaded relief following relief guided by slope contour at about 4°
240	60 m shaded relief following relief guided by boundary between slope classes B and C
241	60 m shaded relief following relief guided by boundary between slope classes C and D
242	60 m shaded relief following relief guided by boundary between slope classes A and B
243	60 m shaded relief following relief guided by slope contour at about 2°
244	60 m shaded relief following relief guided by boundary between relief classes 1 and 2
245	60 m shaded relief following relief guided by boundary between relief classes 2 and 3
246	60 m shaded relief following relief guided by boundary between relief classes 3 and 4

247	60 m shaded relief following relief guided by boundary between relief classes 4 and 5
248	60 m shaded relief following relief guided by 60 m slope
249	60m shaded relief guided by ecoregion and subregion coverage boundaries (Freeouf, 1996)

Table 5. Frequency analysis of source information for arcs of the Buffalo Resource Area Landtype Association coverage.

SOURCE	Freq	Length (m)	Percent of Total
101	105	596,216	4.3
104	466	2,620,102	18.9
107	1	23,714	0.2
109	2	86,428	0.6
220	5	34,828	0.3
221	374	2,243,467	16.2
222	21	126,536	0.9
224	1	596	0.0
232	26	187,926	1.4
236	23	236,604	1.7
239	81	658,776	4.8
240	271	2,544,465	18.4
241	267	3,014,595	21.8
242	162	1,455,920	10.5
249	15	27,943	0.2
Totals	1820	13,858,116	100.0

Table 6. Frequency analysis of source information for arcs of northwest Wyoming Landtype Association coverage.

SOURCE	Freq	Length (m)	Percent of Total
101	64	383,900	1.8
105	38	207,389	1.0
107	55	341,958	1.6
109	34	372,906	1.8
110	83	625,628	3.0
205	8	34,497	0.2
206	1	8,581	0.0
208	179	1,089,822	5.2
220	592	3,056,572	14.5
221	174	887,760	4.2
222	48	289,580	1.4
226	1	3,054	0.0
231	6	34,928	0.2
232	49	161,763	0.8
233	8	32,027	0.2
234	9	48,251	0.2
235	29	184,735	0.9
236	26	153,238	0.7
237	33	221,306	1.0
238	3	34,833	0.2
239	253	1,338,940	6.3
240	412	3,541,404	16.8
241	500	3,539,869	16.8
242	434	3,717,120	17.6
243	16	60,990	0.3
244	16	159,576	0.8
245	38	281,374	1.3
246	29	158,047	0.7
247	6	64,162	0.3
248	3	31,098	0.1
249	12	52,379	0.2
Totals	**6600**	**21,117,688**	**100.0**

NOTE This field contains comments concerning the source of the arc or the criteria used when digitizing the arc.

5.4.3 Sample Records from the Arc Attribute Table

```
               24
FNODE#                       =     5
TNODE#                       =    25
LPOLY#                       =     3
RPOLY#                       =     5
LENGTH                       =     6505.567
ECOUNIT_NW#                  =    24
ECOUNIT_NW-ID                =  5024
TYPE                         =     6
SOURCE                       =   220
NOTE                         = separates rough terrain from smoother terrain to sw, sun in e
DIGITIZER                    = rct


              11
FNODE#                       =    14
TNODE#                       =    16
LPOLY#                       =     9
RPOLY#                       =    25
LENGTH                       =      575.152
ECOUNIT_NE#                  =    11
ECOUNIT_NE-ID                =  9011
TYPE                         =     6
SOURCE                       =   104
NOTE                         = from scoria coverage
DIGITIZER                    = ea
```

5.5 Map Accuracy

There are many factors that affect the accuracy of the delineations in the Landtype Association coverage discussed in Section 5. The main source of error (or uncertainty) is the judgment on our part as to what units should be mapped and the criteria for delineating these units. For each map unit, there was a multitude of decisions to be made. Someone else, using their best judgment, might come up with lines that deviate significantly from ours.

A second source of error is the error associated with the GIS layers used in making the delineations. Table 7 shows the main layers that were used and an estimate of the horizontal accuracy for each layer. Some of the arcs in the Landtype Association coverage were taken directly from the coverages in Table 7, so the errors associated with these arcs carried over to the Landtype Association coverage. Other arcs were digitized on-screen with a variety of background displays. In this case, there was not only the error associated with the GIS layer used for the background display, but also a digitizing error. The most common background display was shaded relief derived from 60 m DEM data, with the display zoomed to a scale of about 1:24,000. Slope and local relief classes were displayed on top of the shaded relief with a hatched pattern to guide digitizing. When there were distinct topographic features to follow, the lines drawn were within 1 to 2 pixels of the desired location (60-120 m with 60 m DEM data). When the features were less distinct, the position of the line involved more judgment. Often, selected geology polygons were displayed on top of the shaded relief with hatched patterns to guide the digitizing. In this situation, the horizontal accuracy could vary significantly depending on whether the delineation closely followed the relief or the geology.

Since the accuracy associated with a given delineation depends on many factors and since these factors may vary for different parts of the delineation, it is difficult to specify a single number that reflects the true accuracy situation. Lines based on distinct features visible in the 30 m shaded relief displays are going to be more accurate than lines based on 60 m data or lines based on the geology coverage or the hydrologic units coverage. In an effort to document the source/criteria for each delineation and to provide some sense of accuracy, the arcs in the Landtype Association coverage were attributed with a 3-digit code in the SOURCE field. A list of these codes is presented in Section 5.4.2. Codes ranging from 101 to 199 indicate lines obtained directly from other coverages, while codes from 201 to 299 indicate lines digitized on-screen with the specified background display. In addition to the SOURCE field, each arc has a NOTE field that contains a brief description of the criteria used in making the delineation.

Table 7. Estimates of the horizontal accuracy of the GIS layers used in the delineations of the Landtype Association coverage.

GIS Layer	Horizontal Accuracy Estimate [m]	See Note	Other Comments
Counties	±50	1	Digitized from 1:100,000 source materials
DEM (7.5-minute)	±15	2	30 m cell size
DEM (1°X2°)	±100	2	Approximately 90 m cell size
Geology	±700	3	Digitized from 1:500,000 source materials
Hydrography	±50	2	USGS 1:100,000 digital line graphs (DLG)
Hydrologic units	±700	4	Digitized from 1:500,000 source materials
Land Cover	±250	3	Derived from 100 m thematic mapper data
Soils	±500		Digitized from 1:500,000 and 1:250,000 source materials
Surficial Geology	±700	3	Digitized primarily using NHAP photography onto a 1:500,000 base map
Thematic mapper	±200	3	Original data were not terrain corrected and were resampled to 100 m

Notes

1. Accuracy estimate based on the assumption of a 0.5 mm digitizing error.

2. Accuracy estimate from the "Geo-Positioning Selection Guide" developed by the US Department of Interior, Bureau of Land Management (US Government Printing Office: 1992-676-687).

3. Accuracy estimate based on a comparison of the positions of large lakes and reservoirs and major rivers in the GIS layer with the positions of the corresponding features in the USGS 1:100,000 hydrography DLG coverage.

4. Accuracy estimate based on a comparison of the line along the Continental Divide in the Wind River Range with the corresponding line in the counties coverage, which forms the boundary between Sublette and Fremont counties.

In view of the uncertainties associated with the delineations, it may be helpful to think of the lines as fuzzy lines with varying widths that depend on the many factors affecting accuracy, with the possibility that the position and widths of these lines may significantly change as judgment evolves or better data become available.

6. CONTRACT PRODUCTS

Contract products accompanying this report include the following items:

a) Five bound copies of this report,
b) One loose-leaf copy of this report for reproduction,
c) Digital data in Arc/Info format for Landtype Association coverage for northwest Wyoming and the Buffalo Resource Area, Shoshone National Forest Landtype Association coverage, Bridger-Teton National Forest Landtype Association coverage, Bighorn National Forest Landtype Association coverage and the major GIS layers including bedrock geology, landcover, DEMs, surficial geology, soils, and annual precipitation along with a data dictionary describing the data,
d) A single map of the Landtype Associations of Wyoming for the current and previous project areas, as well as US Forest Service Landtype Associations on 36" wide paper,
e) One set of aerial color slides showing all Landtype Associations in Northwest Wyoming and the Buffalo Resource Area

7. LITERATURE CITED

Anonymous. 1994. Ecosystem management in the BLM: from concept to commitment. Dept. of Interior, Bureau of Land Management BLM/SC/GI-94/005+1736. Government Printing Office. 16 p.

Bailey, R.G. 1980. Descriptions of the ecoregions of the United States. USDA Forest Service; Misc. Publ. No. 1391. 77 p plus map.

Bailey, R.G. 1995. Description of the ecoregions of the United States. USDA Forest Service Miscellaneous Publication 1391 (rev.). Washington, D.C. 108 p. plus map at 1:7,500,000.

Bailey, R.G. 1996. Ecosystem geography. New York: Springer-Verlag. 204 p.

Blaszczynski, J.S. 1997. Land form characterization with geographic information systems. Photogrammetric Engineering & Remote Sensing 63:183-191.

Bourgeron, P.S., H.C. Humphries, and M.E. Jensen. 1994. Landscape characterization: a framework for ecological assessment at regional and local scales. Journal of Sustainable Forestry 2(3/4):267-281.

Brown, W.G. 1993. Structural style of Laramide basement-cored uplifts and associated folds, pp. 312-371. In Snoke, A.W.; J.R. Steidtmann, and S.M. Roberts (eds.) Geology of Wyoming, Vol. 1. Geological Survey of Wyoming, Laramie, WY.

Capen, D.E., C.E. Ferree, E.W. Buford, E.H. Thompson. 1999. Landscape analysis in support of biodiversity planning. Abstract. 1999 National Gap Meeting. Duluth, MN. 2-6 August 1999.

Case, J.C., C.S. Arneson, and L.L. Hallbe. 1998. Wyoming Surficial Geology. Spatial Data and Visualization Center, Laramie, Wyoming.

Changnon, S.A. and M. Demissie. 1996. Detection of changes in streamflow and floods resulting from climate fluctuations and land-use drainage changes. Climatic Change 32(4):411-421.

Daly, C., R.P. Neilson, and D.L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology 33(2):140-158.

Davis, F.W. and J. Dozier. 1990. Information analysis of a spatial database for ecological land classification. Photogrammetric Engineering and Remote Sensing 56(5):605-613.

Driese, K.L., W.A. Reiners, E.H. Merrill, and K.G. Gerow. 1997. A digital land cover map of Wyoming, USA: a tool for vegetation analysis. Journal of Vegetation Science 8(1):133-146.

ECOMAP. 1993. National hierarchical framework of ecological units. Washington, D.C. ECOMAP, U.S.D.A. Forest Service. 20 p.

Fairbridge, R.W. (ed.) 1968. The Encyclopedia of Geomorphology. Encyclopedia of Earth Science Series, Vol. 111. Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA. 1295 p.

Fels, J.E. and K.C. Matson. 1996. A cognitively-based approach for hydrogeomorphic land classification using digital terrain models. Third International Conference/Workshop on Integrating GIS and Environmental Modeling, Santa Fe, NM. CD-rom.

Freeouf, J.A. 1996. Ecoregions and subregions of Region 2 - Subsections. State of Wyoming. 1:1,000,000 map revised May 1996. U.S.D.A. Forest Service, Rocky Mountain Region, Denver, CO.

Godfrey, A.E. and E.T. Cleaves. 1991. Landscape analysis: theoretical considerations and practical needs. Environmental Geology and Water Science. 17: 141-156.

Green, G.N. and P.H. Drouillard. 1994. The digital geologic map of Wyoming in ARC/INFO format. Open-file Report 94-0425. U.S. Department of Interior, U.S. Geological Survey. Denver, CO. 12 p.

Hammond, E.H. 1964. Analysis of properties in land form geography: an application to broad-scale land form mapping. Annals of the Association of American Geographers 54:11-23. Map supplement no. 4. Classes of land-surface form in the forty-eight states, USA. 1:5,000,000.

Hammond, E.H. 1970. Classes of land-surface form. In: The National Atlas of the USA. Map scale 1:7,500,000. U.S. Geological Survey, Washington, D.C.

Heffern, E.L. and D.A. Coates. 1997. Clinker -- Its occurrence, uses, and effects on coal mining in the Powder River Basin. Wyoming State Geological Survey Public Infomration Circular 38.

Host, G.E., P.L. Polzer, D.J. Mladenoff, M.A. White, and T.R. Crow. 1996. A quantitative approach to developing regional ecosystem classifications. Ecological Applications 6(2):608-618.

Knight, D.H. 1994. Mountains and plains. The ecology of Wyoming landscapes. Yale University Press, New Haven, CT. 338 p.

Lageson, D.R. and D.R. Spearing. 1988. Roadside geology of Wyoming. 2nd ed. Mountain Press Publishing Co. Missoula, MT. 271 p.

Lillegraven, J.A. 1993. Correlation of Paleogene strata across Wyoming--a users' guide, pp. 414-477. *In* Snoke, A. W., J.R. Steidtmann, and S.M. Roberts (eds.). Geology of Wyoming Vol. 1. Geological Survey of Wyoming, Laramie, WY.

Lillegraven, J.A. and A.W. Snoke. 1996. A new look at the Laramide orogeny in the Seminoe and Shirley Mountains, Freezeout Hills, and Hanna Basin, south-central Wyoming. Public Information Circular No. 36. Wyoming State Geological Survey; Laramie, WY. 52 p.

Lotspeich, F.B. 1998. Planning for geoclimatic land management to attain environmental sustainability: a universal system for all land resources. Bull. Ecol. Soc. Amer. 79(1): 132-134.

Love, J.D. 1970. Cenozoic geology of the Granite Mountains area, central Wyoming. U.S. Geological Survey Professional Paper 495-C. Dept. of Interior, U.S. Geological Survey. 154 p.

Love, J.D. and A.C. Christiansen. 1985. Geologic map of Wyoming. 1:500,000 map. U.S. Dept. of Interior, U.S. Geological Survey, Denver, CO.

Madole, R.F., W.C. Bradley, D.S. Loewenherz, D.F. Ritter, N.W. Rutter and C.E. Thorn. 1987. Rocky mountains, pp. 211-257. *In* W.L. Graf (ed.) Geomorphic systems of North America. Geological Society of America, Centennial Special Volume 2. Boulder, CO.

Mann, S. and G.L. Benwell. 1996. The integration of ecological neural and spatial modelling for monitoring and prediction for semi-arid landscapes. Computers and Geosciences 22:1003-1012.

McNab, W.H. and P.E. Avers. 1994. Ecological subregions of the United States: Section descriptions. U.S.D.A. Forest Service, WO-WSA-5. Washington, D.C. 267 p.

Mears, B., Jr. Geomorphic history of Wyoming and high-level erosion surfaces, pp. 608-626. *In* A.W. Snoke, J. R. Steidtmann and S.M. Roberts (eds.). Geology of Wyoming. Geological Survey of Wyoming Memoir No. 5.

Medler, M.J. and S.R. Yool. 1998. Computer-assisted terrain stratification. Physical Geography 19:433-443.

Merrill, E.H., T.W. Kohley, M.E. Herdendorf, W.A. Reiners, K.L. Driese, R.W. Marrs, and S.H. Anderson. 1996. The Wyoming Gap Analysis Project. Final Report. Wyoming Cooperative Fish and Wildlife Unit, Laramie, WY. 4 volumes.

Munn, L.C. and C.S.. Arneson. 1998. 1:500,000-Scale Digital Soils Map of Wyoming: University of Wyoming Agricultural Experiment Station, Laramie, Wyoming.

Omernik, J.M. and R.G. Bailey. 1997. Distinguishing between watersheds and ecoregions. Journal of the American Water Resources Association 35: 935-949.

Osterkamp, W.R., M.M. Fenton, T.C. Gustavson, R.F. Hadley, V.T. Holliday, R.B. Morrison and T.J. Toy. 1987. Great plains, pp. 163-210. *In* Graf, W. L. (ed.). Geomorphic systems of North America. Centennial Special Volume 2. Geological Society of America, Boulder, CO.

Reiners, W.A. and R.C. Thurston. 1994. Delineations of ecosystem boundaries within the Buffalo Resource Area of the BLM. Report to the State Office of the Bureau of Land Management. Laramie, WY: The University of Wyoming. 21 p.

Reiners, W.A. and R.C. Thurston. 1995. Delineations of landtype associations within the Great Plains Physiographic Province of Wyoming. Final Report to the Bureau of Land Management, Contract K-910-P40261. 65 p.

Reiners, W.A. and R.C. Thurston. 1996. Delineations of landtype associations for southeast Wyoming. Final Report to the Bureau of Land Management, Contract K-910-P960124. 92 p. plus Appendix.

Reiners, W.A. and R.C. Thurston. 1997. Delineations of landtype associations for southwest Wyoming. Final Report to the Bureau of Land Management, Contract K-910-P50082. 82 p. plus Appendix.

Royse, F. Jr. 1993. An overview of the geologic structure of the thrust belt in Wyoming, northern Utah, and eastern Idaho, pp 272-311. *In* A.W. Snoke, J. R. Steidtmann and S.M. Roberts (eds.). Geology of Wyoming. Geological Survey of Wyoming Memoir No. 5.

Smith, R.B., J.O.D. Byrd and D.D. Susong. 1993. The Teton fault, Wyoming: seismotectonics, Quaternary history, and earthquake hazards, pp. 628-667. *In* A.W. Snoke, J. R. Steidtmann and S.M. Roberts (eds.). Geology of Wyoming. Geological Survey of Wyoming Memoir No. 5.

U.S. Geological Survey. 1994. Bedrock Geology of Wyoming. Dept. of Interior. U.S. Geological Survey. Denver, CO.

U.S. Geological Survey. 1987. Digital elevation models. Data Users Guide. Dept. of Interior, U.S. Geological Survey. Reston, VA.

U.S. Geological Survey. 1989. Digital line graphs from 1:100,000-scale maps. Data Users Guide. Dept. of Interior, U.S. Geological Survey. Reston, VA.

U.S. Geological Survey. 1976. Hydrologic unit map - 1974. State of Wyoming. Dept. of Interior, U.S. Geological Survey. Reston, VA.

8. FIGURES

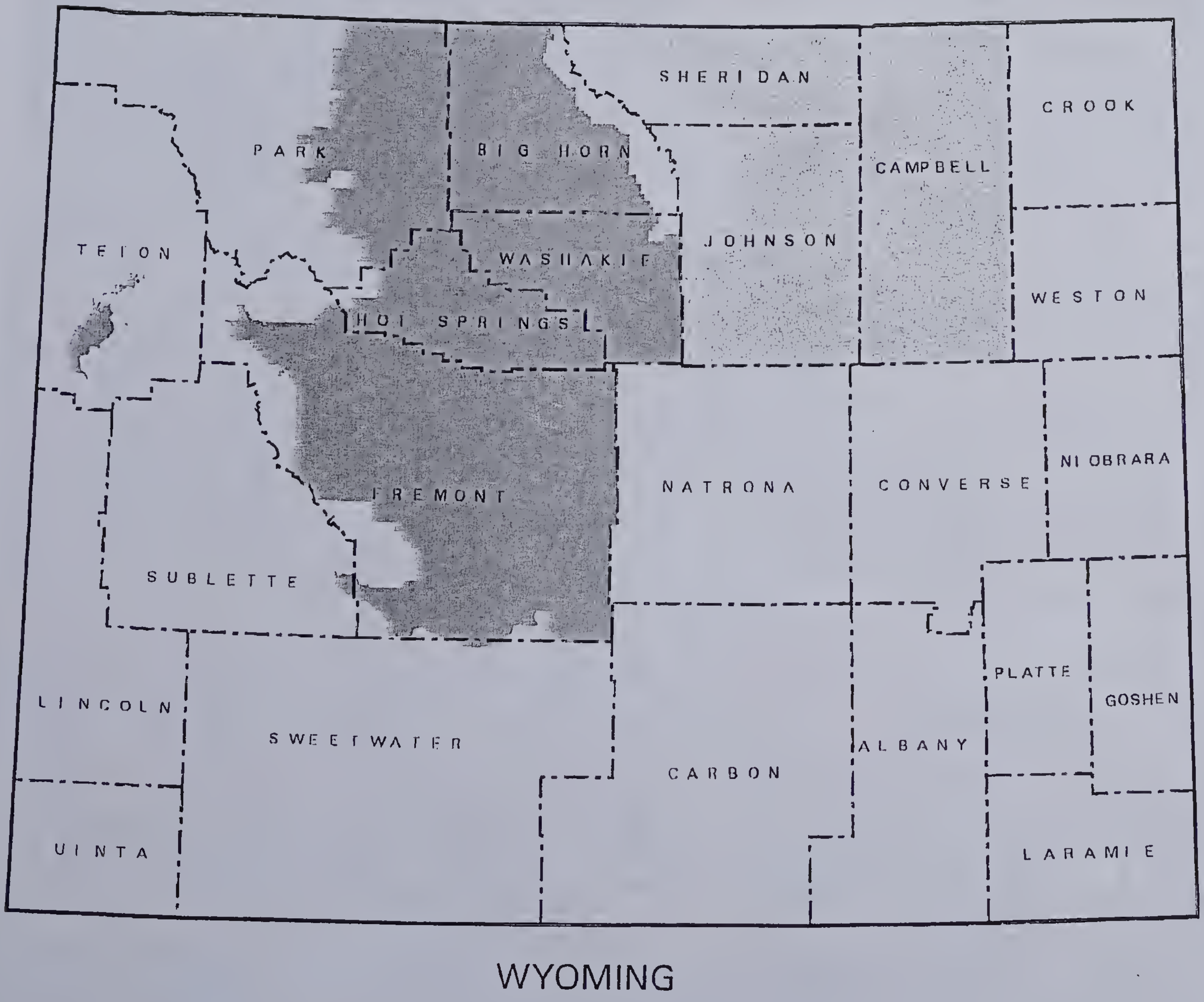


Fig. 1. Area of the state mapped in this report.

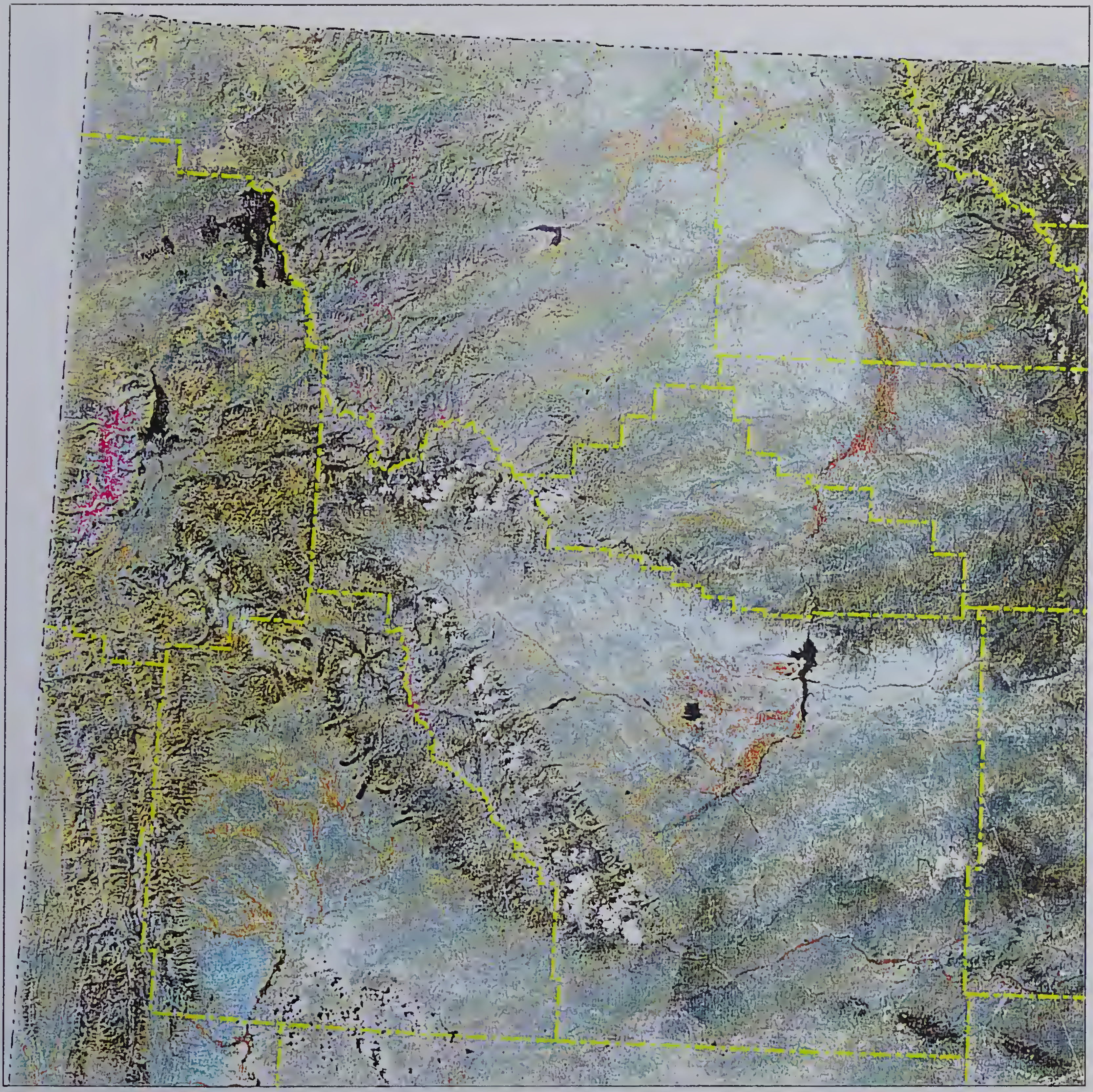


Fig. 2. Mosaic of thematic mapper data for northwest Wyoming with bands 4, 5 and 3 rendered in red, green and blue, respectively.

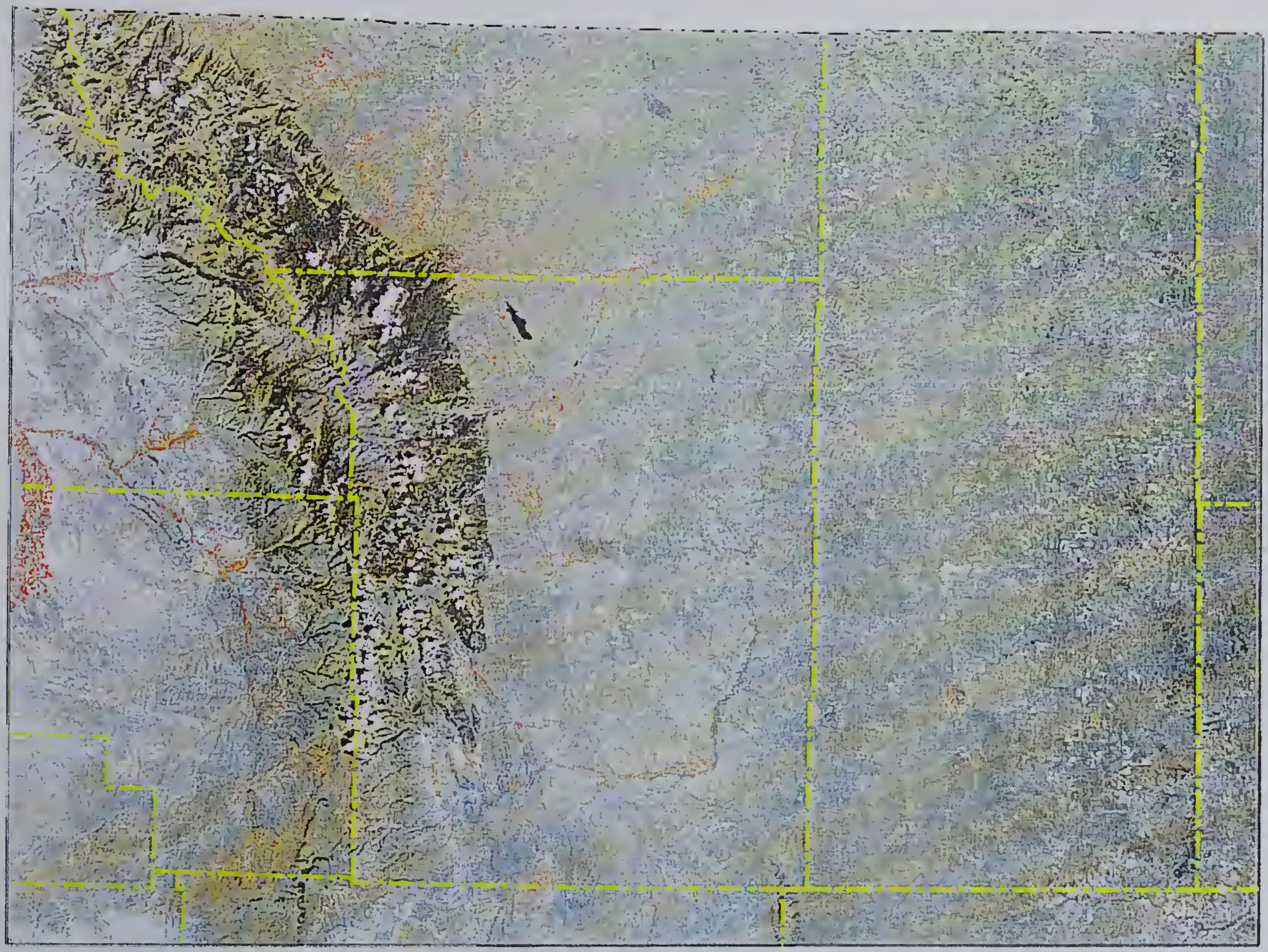


Fig. 3. Mosaic of thematic mapper data for the Buffalo Resource Area with bands 4, 5 and 3 rendered in red, green and blue, respectively.

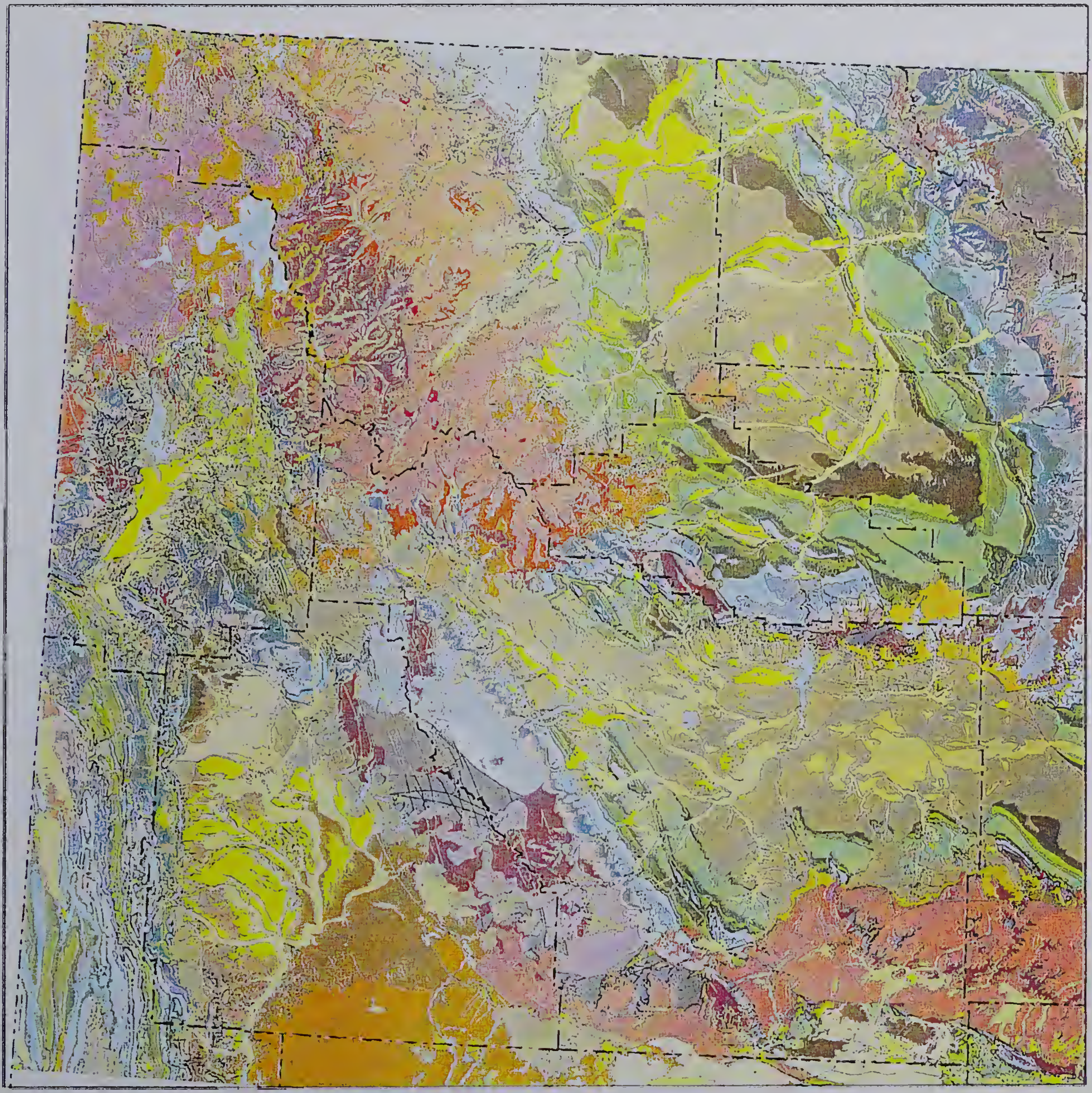


Fig. 4. Geology of northwest Wyoming derived from Love and Christiansen (1985). The legend for the map is not shown due to the number of geologic units and the map scale. For unit identification see Love and Christiansen (1985).

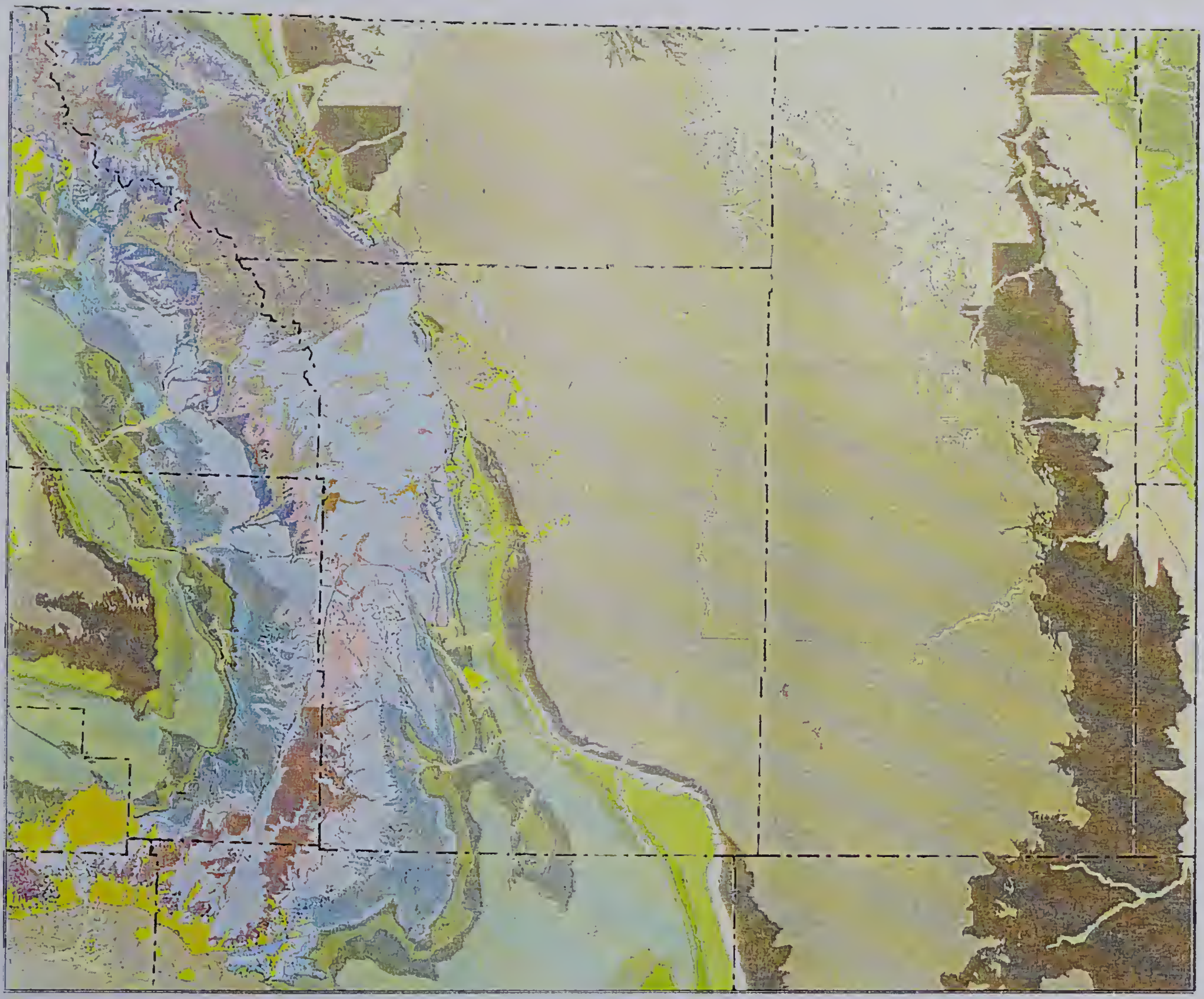


Fig. 5. Geology of the Buffalo Resource Area derived from Love and Christiansen (1985). The legend for the map is not shown due to the number of geologic units and the map scale. For unit identification see Love and Christiansen (1985).

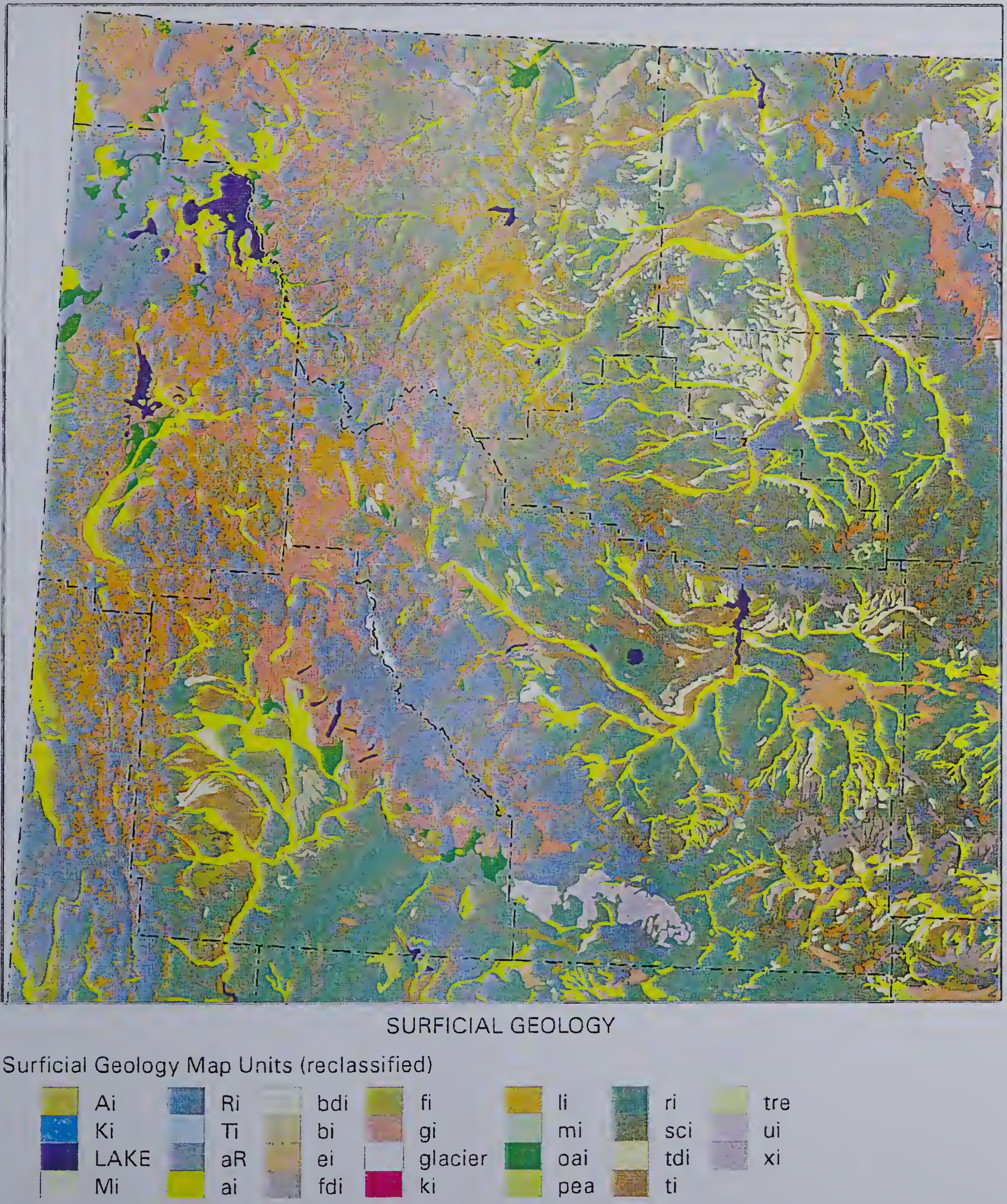


Fig. 6. Surficial geology of northwest Wyoming from Case et al. (1998). Table 5 of the Appendix provides an explanation of the reclassified mapping unit codes.

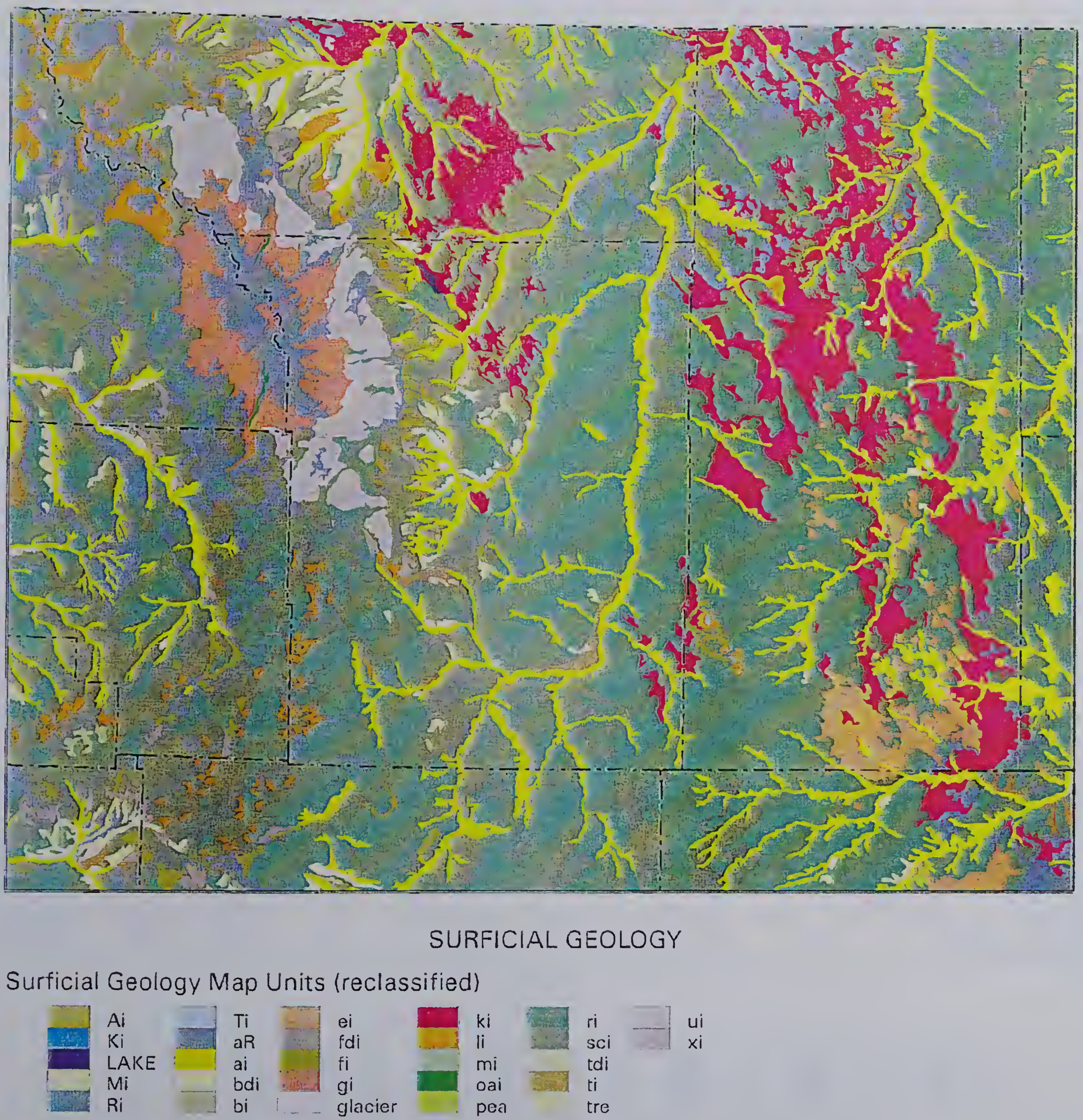


Fig. 7. Surficial geology of the Buffalo Resource Area from Case et al. (1998). Table 5 of the Appendix provides an explanation of the reclassified mapping unit codes.

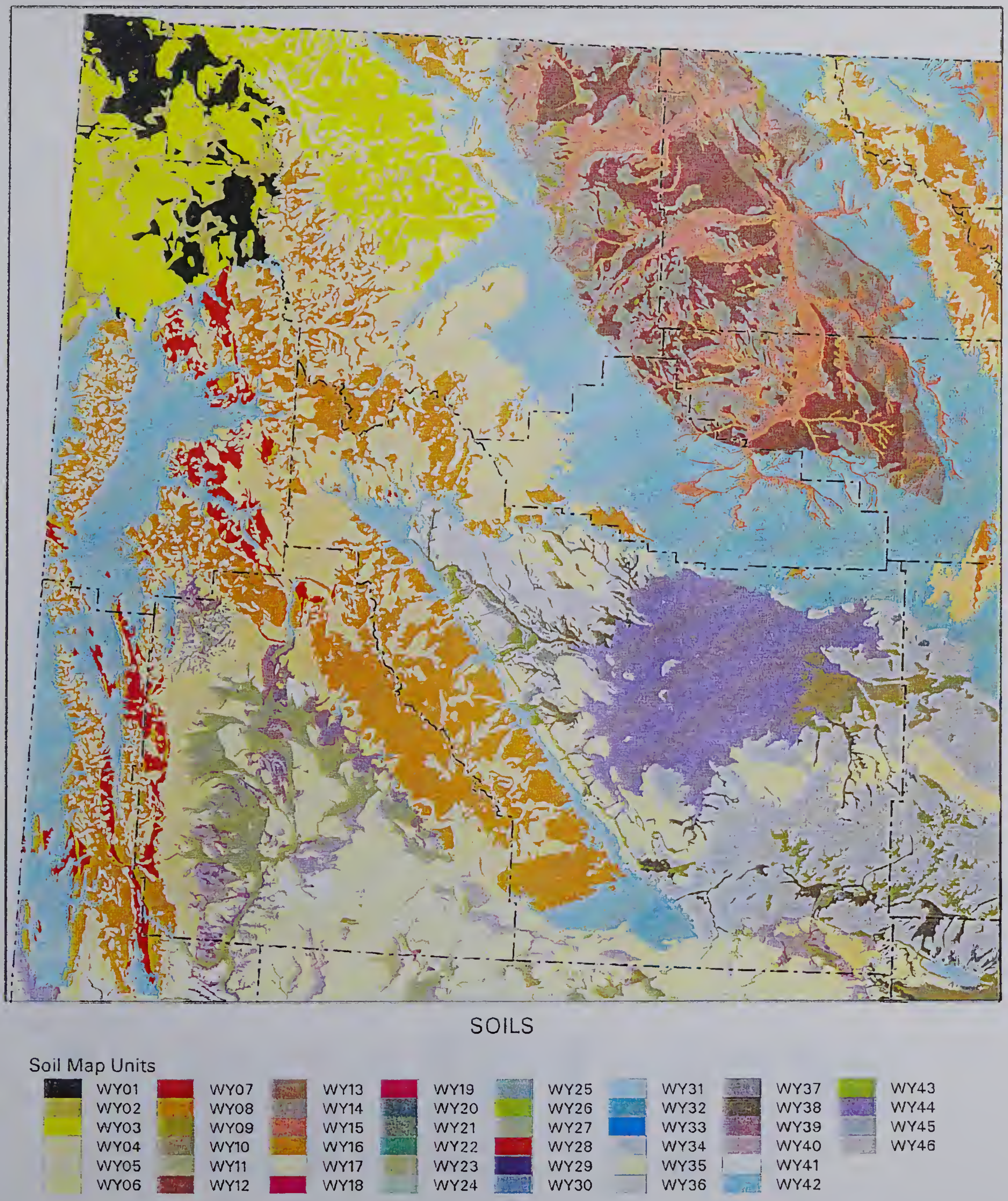


Fig. 8. Soil types of northwest Wyoming from Munn and Arneson (1998). Table 7 of the Appendix provides an explanation of the soil mapping unit codes.

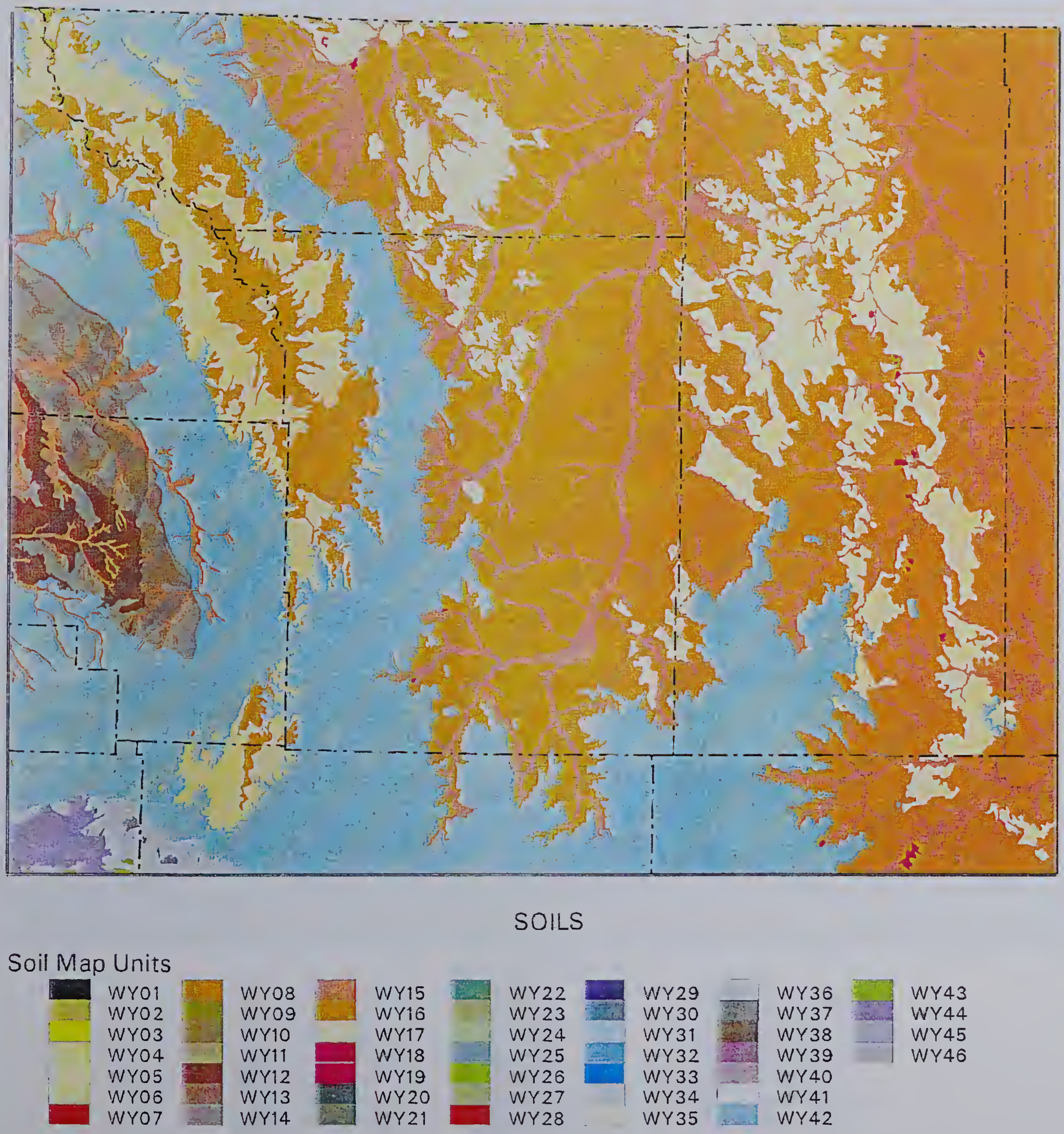


Fig. 9. Soil types of the Buffalo Resource Area from Munn and Arneson (1998). Table 7 of the Appendix provides an explanation of the soil mapping unit codes.

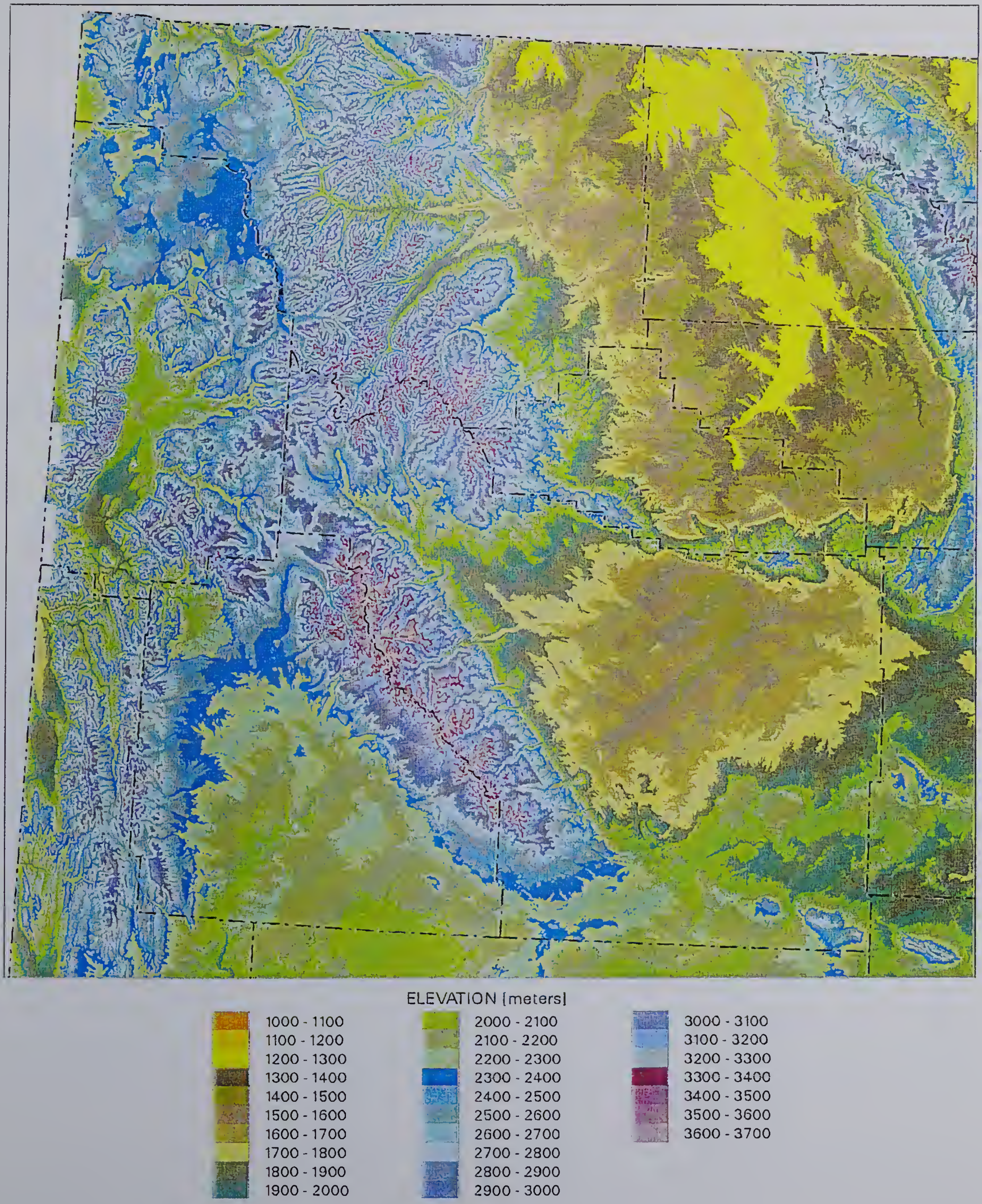


Fig. 10. Elevations for northwest Wyoming as they occur in 100 m intervals derived from 60 m DEM data.

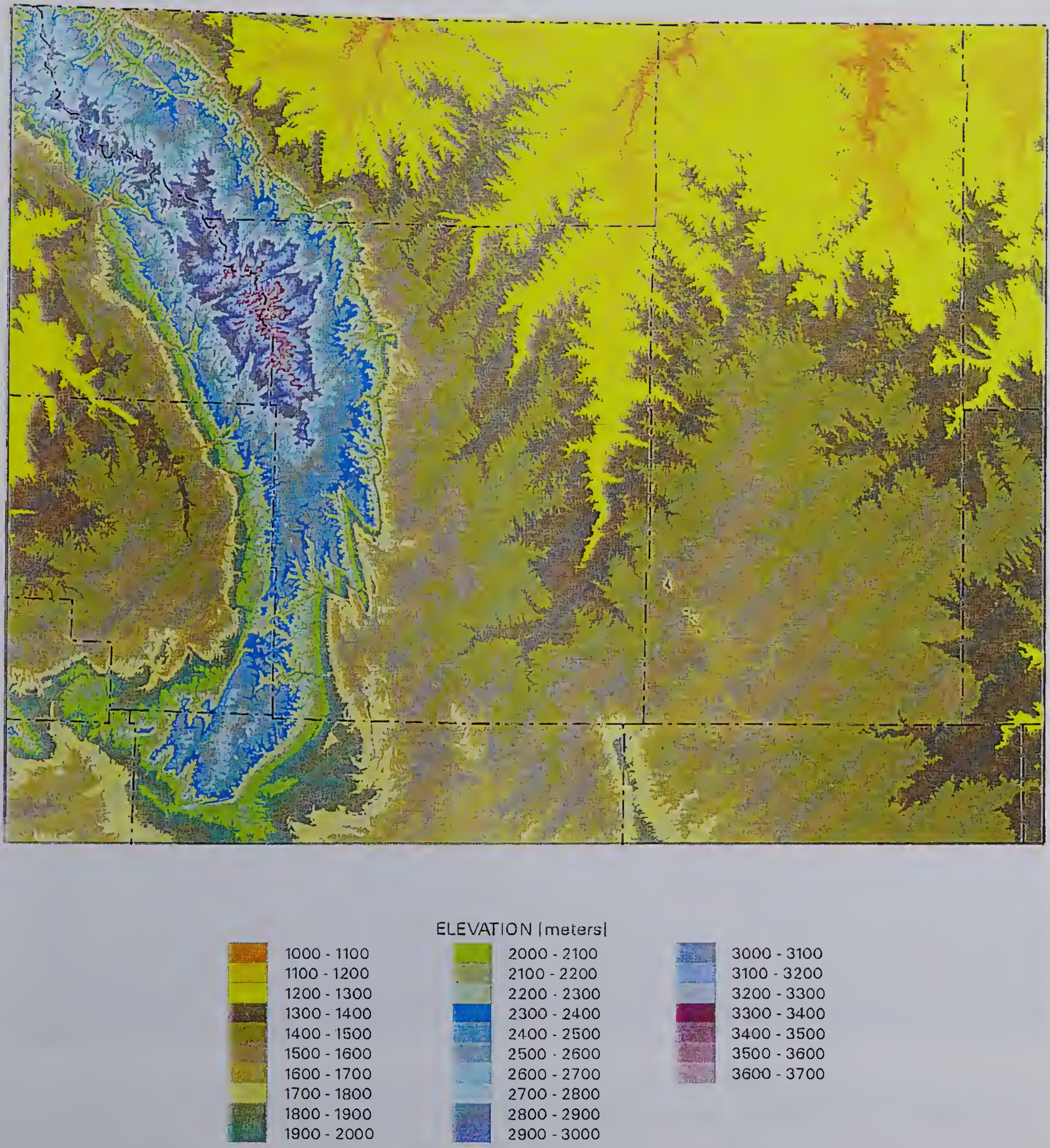


Fig. 11. Elevations for the Buffalo Resource Area as they occur in 100 m intervals derived from 60 m DEM data.

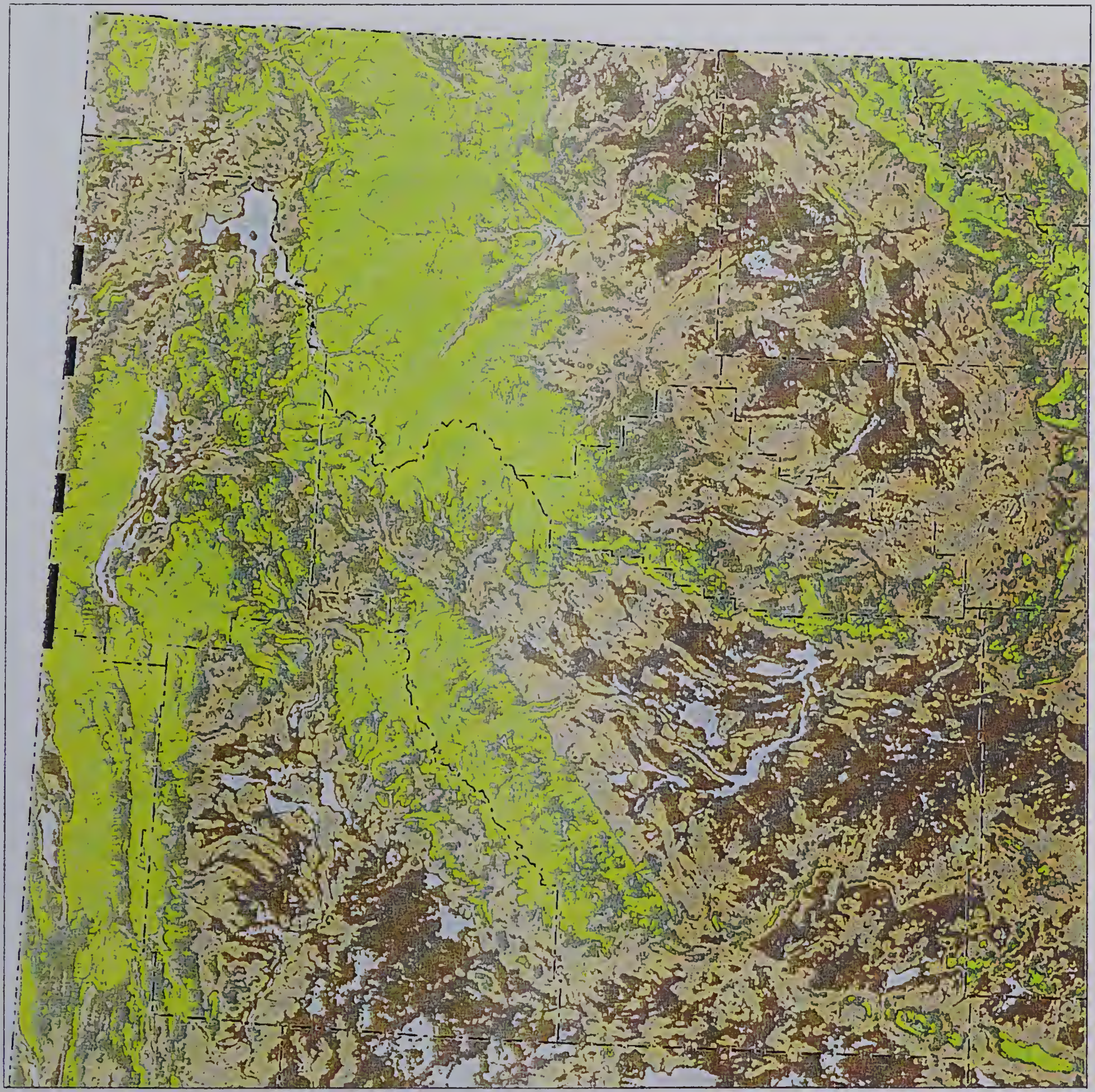


Fig. 12. Local relief of northwest Wyoming derived from 60 m DEM data and used for Hammond classification. Bright green areas indicate highest local relief. Grey/blue areas indicate lowest local relief.

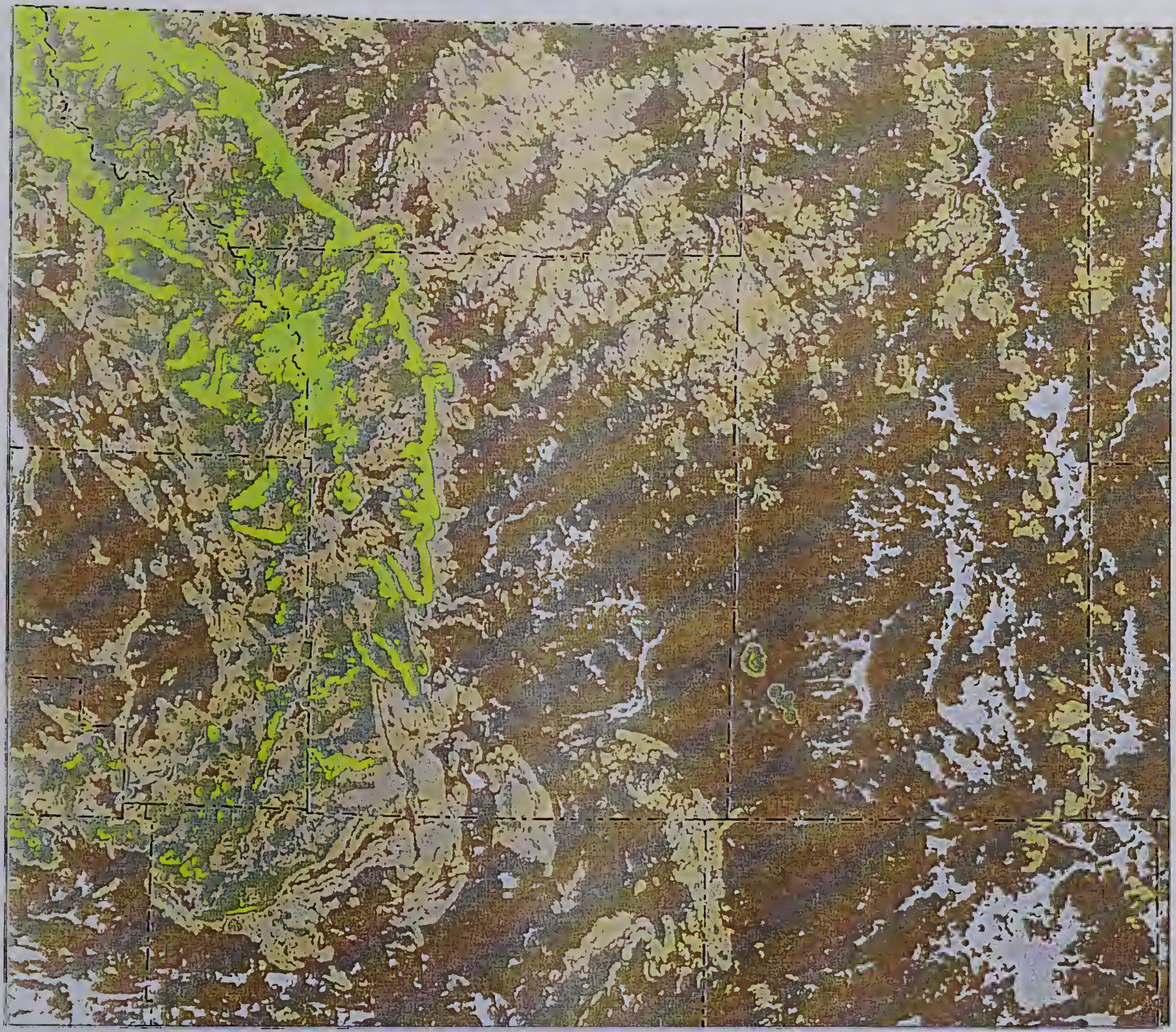


Fig. 13. Local relief of the Buffalo Resource Area derived from 60 m DEM data and used for Hammond Classification. Bright green areas indicate highest local relief. Grey/blue areas indicate lowest local relief.

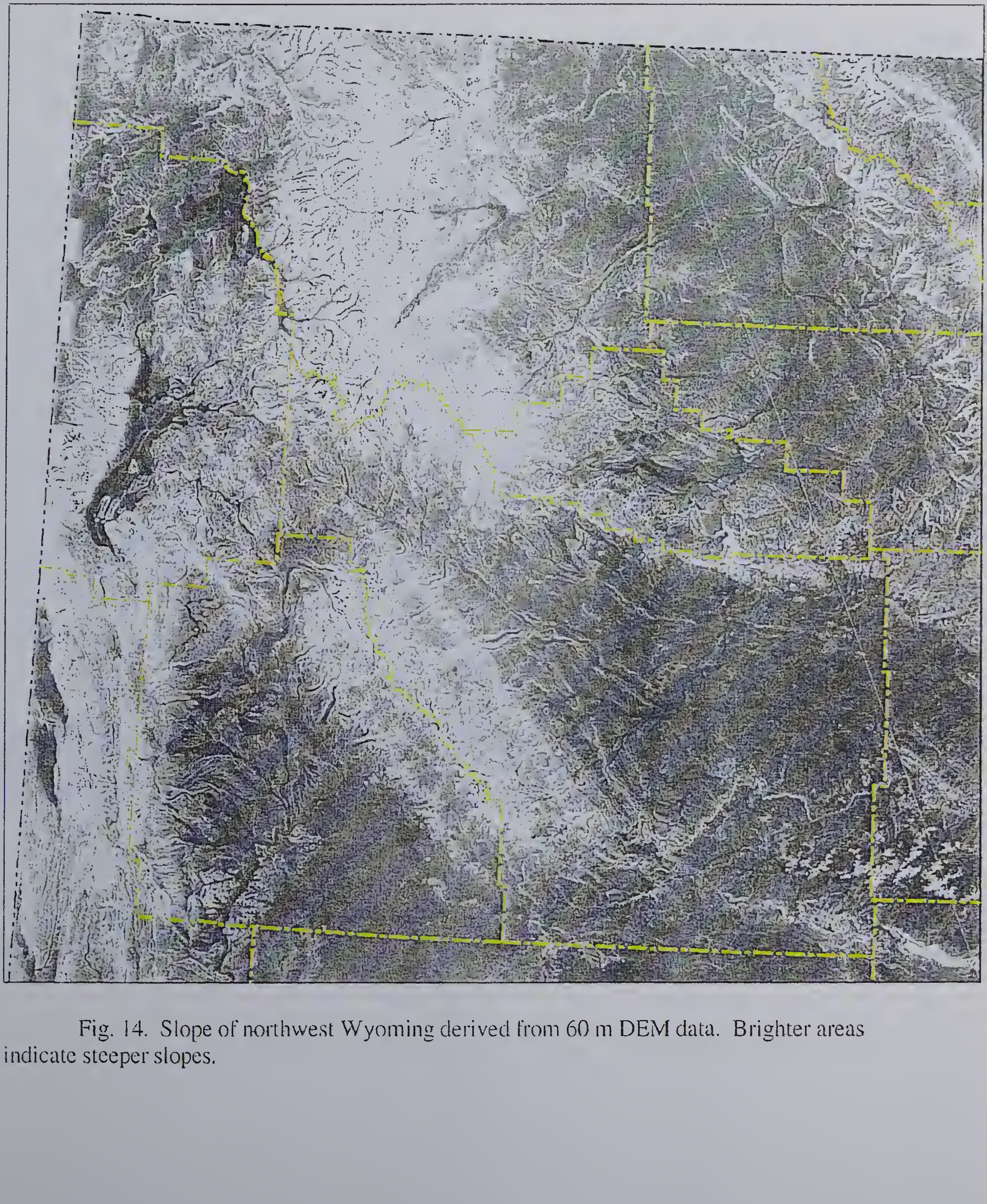


Fig. 14. Slope of northwest Wyoming derived from 60 m DEM data. Brighter areas indicate steeper slopes.

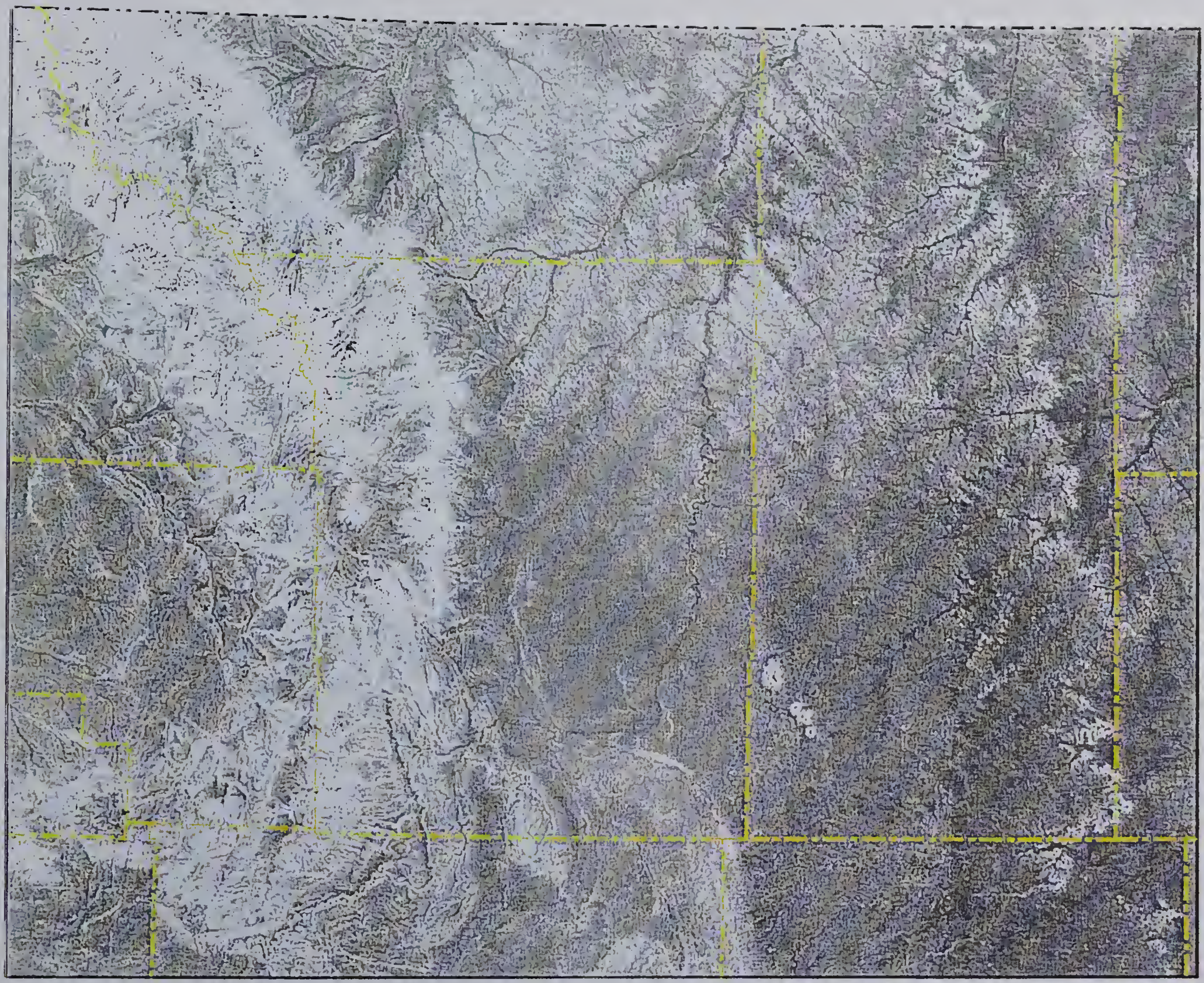


Fig. 15. Slope of the Buffalo Resource Area derived from 60 m DEM data. Brighter areas indicate steeper slopes.

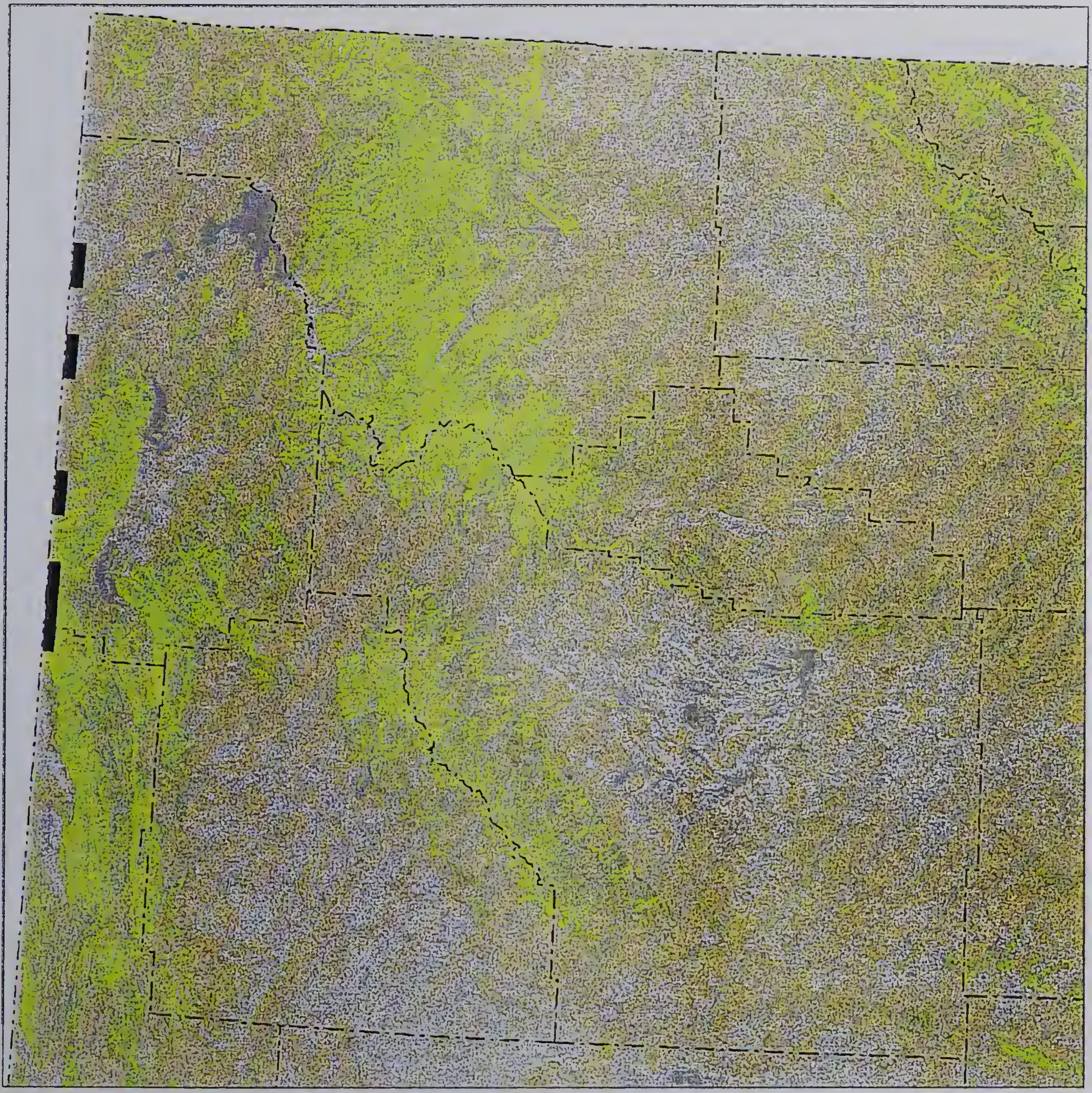


Fig. 16. Slope of northwest Wyoming derived from 60 m DEM data and used for Hammond Classification. Bright green areas indicate steeper slopes. Grey areas indicate gentle slopes.

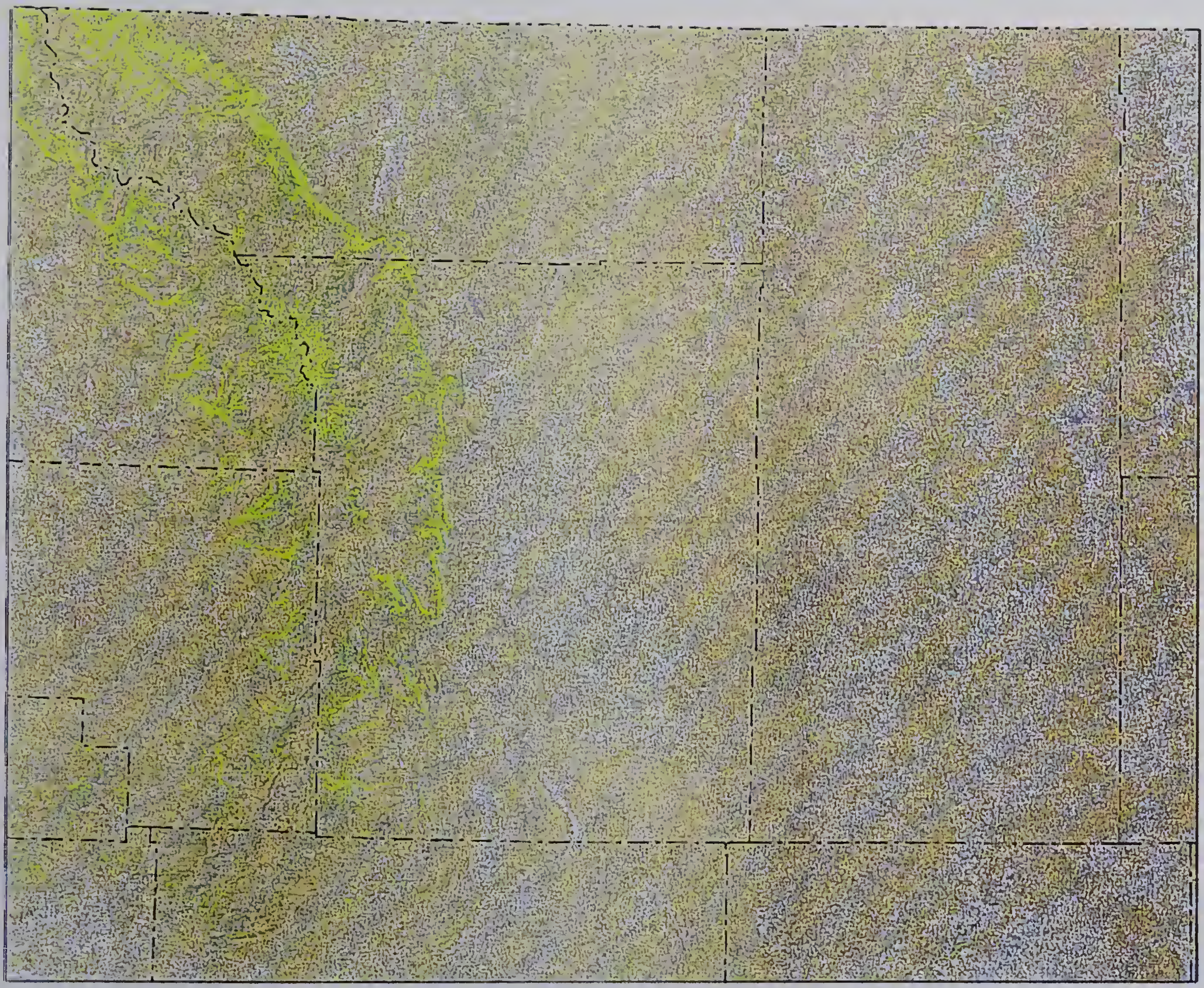


Fig. 17. Slope of the Buffalo Resource Area derived from 60 m DEM data and used for Hammond classification. Bright green areas indicate steeper slopes. Grey areas indicate gentle slopes.

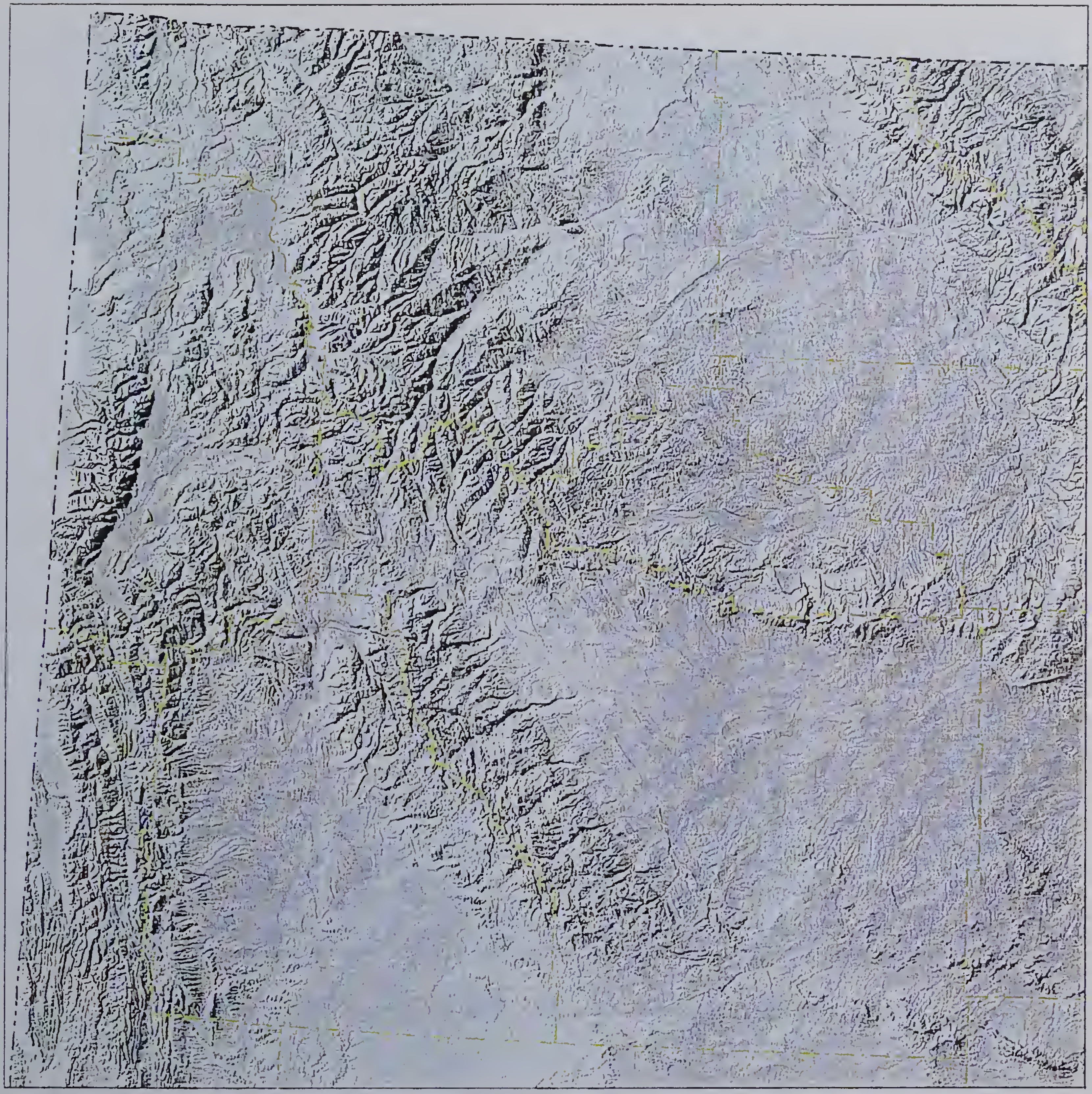


Fig. 18. Shaded relief of northwest Wyoming derived from 60 m DEM data.

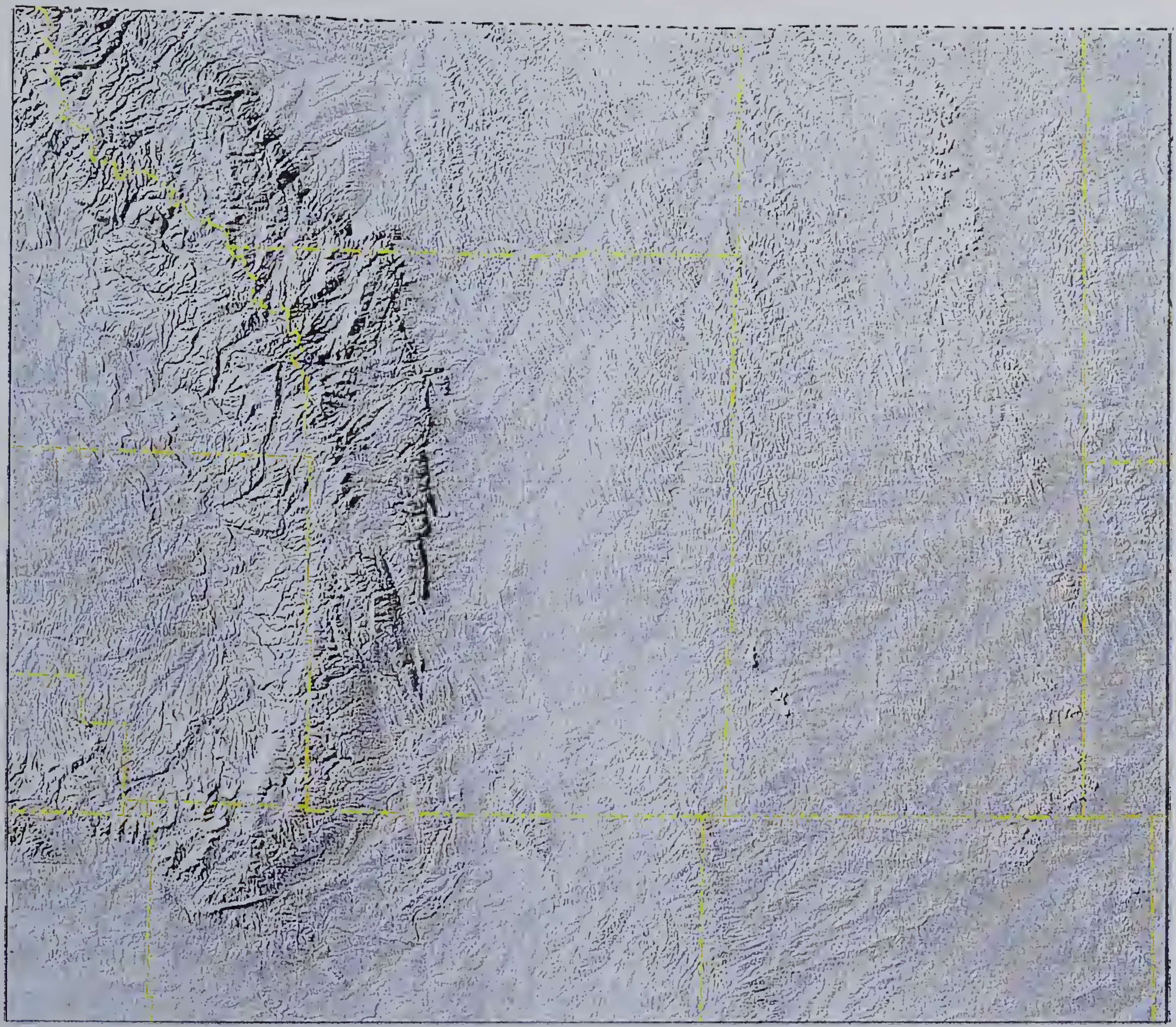


Fig. 19. Shaded relief of the Buffalo Resource Area derived from 60 m DEM data.

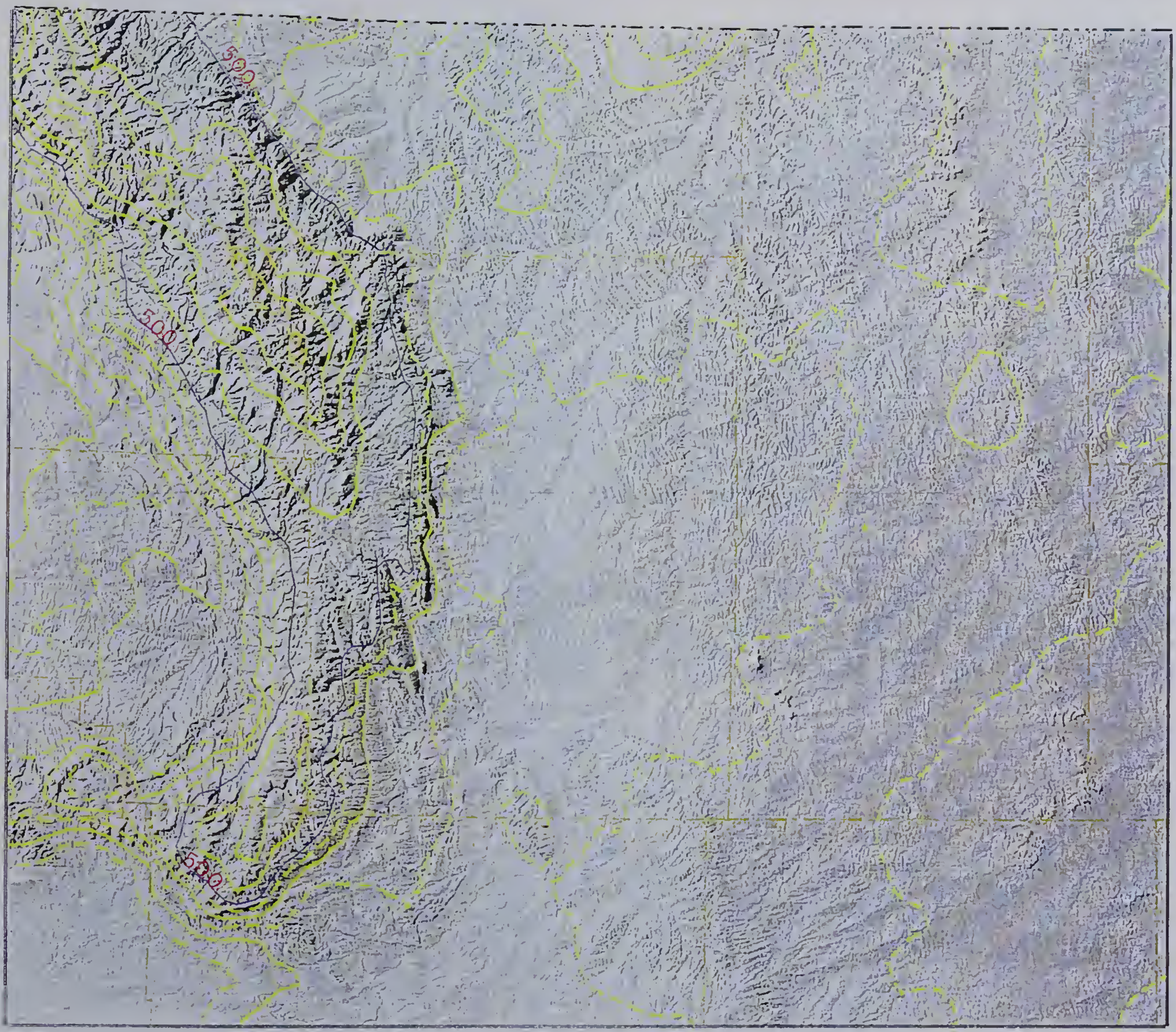


Fig. 21. Mean annual precipitation isolines for the Buffalo Resource Area shown over shaded relief. The isoline interval is 100 mm, with supplementary isolines (dashed lines) at 50 mm intervals. Precipitation values in millimeters are shown for the index isolines.

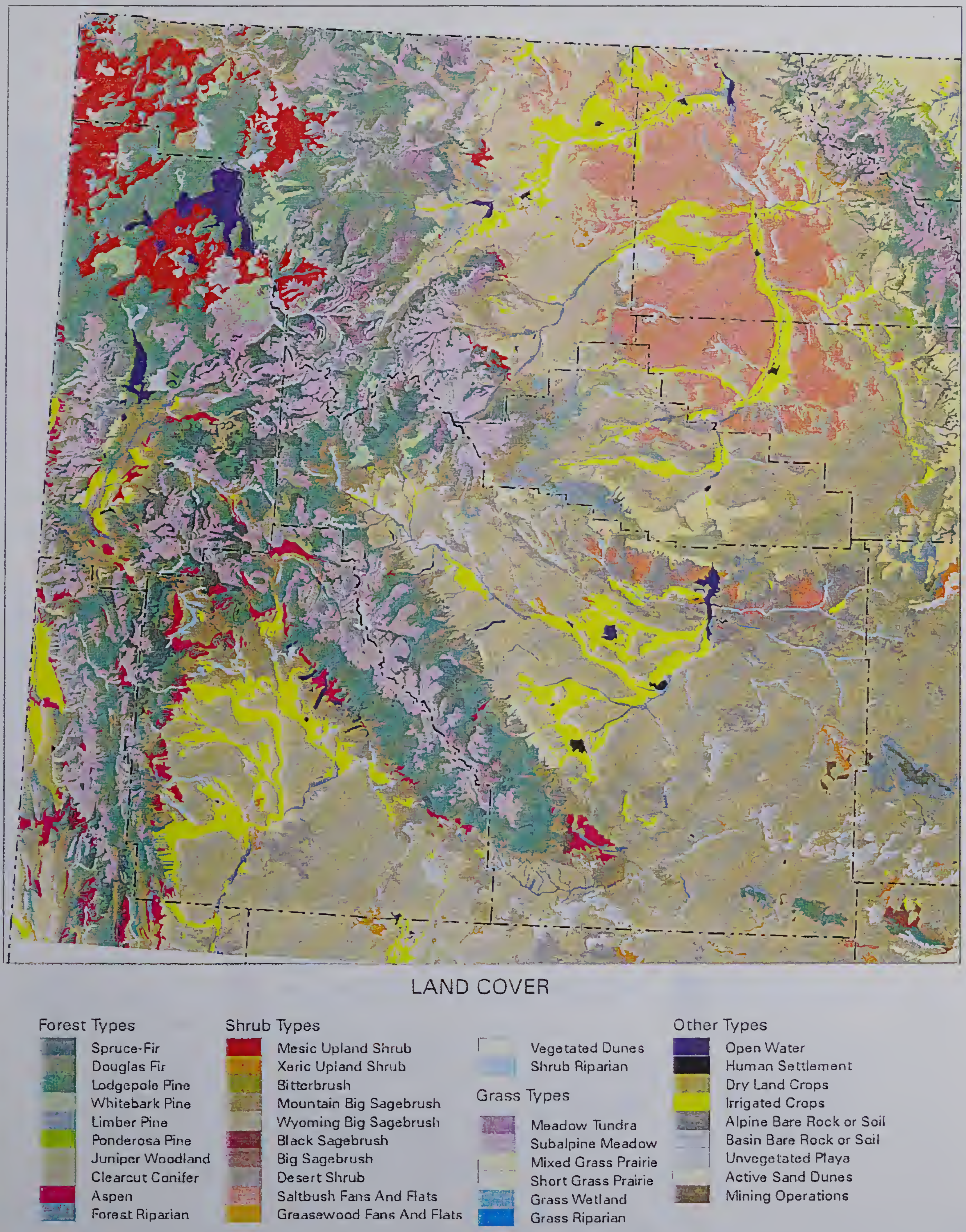


Fig. 22. Land cover of northwest Wyoming derived from Wyoming GAP land cover map (Driese et al. 1997).

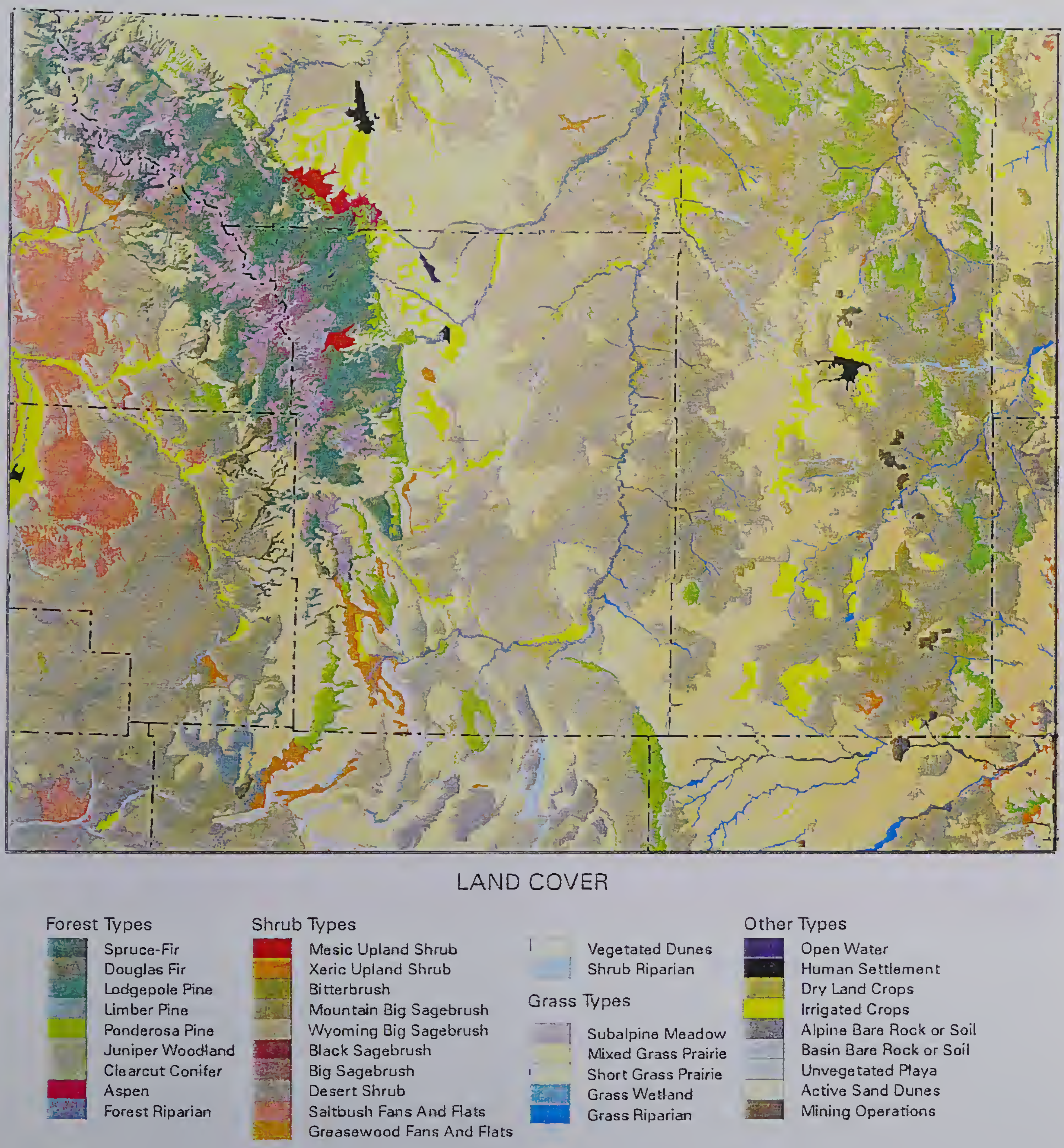
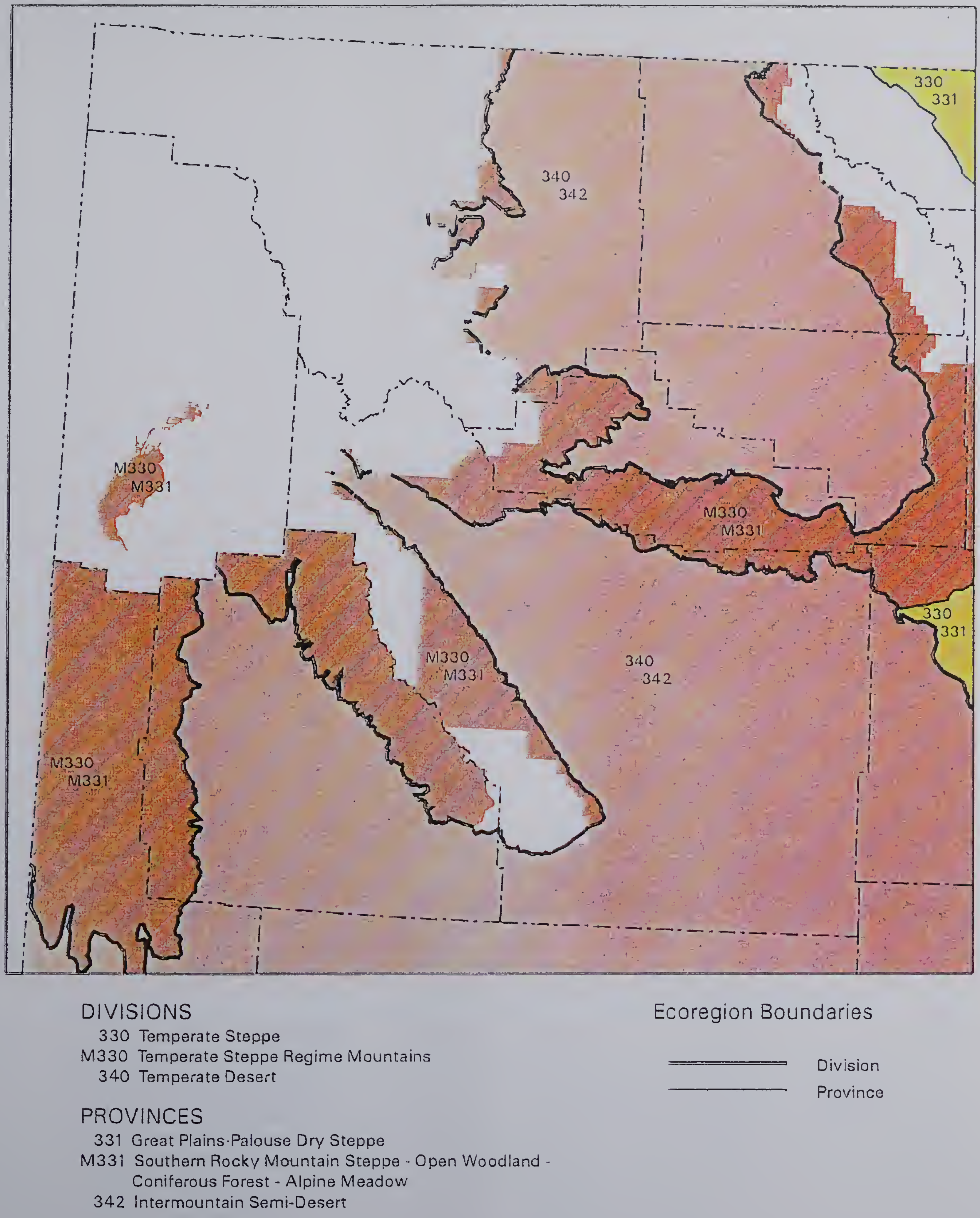


Fig. 23. Land cover of the Buffalo Resource Area derived from Wyoming GAP land cover map (Driese et al., 1997).


330
331
340
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M330
M331
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M331
M330
M331
340
342
330
331
M330
M331
DIVISIONS
330 Temperate Steppe
M330 Temperate Steppe Regime Mountains
340 Temperate Desert
PROVINCES
331 Great Plains-Palouse Dry Steppe
M331 Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow
342 Intermountain Semi-Desert
Ecoregion Boundaries
Division
Province

Fig. 24. Divisions and Provinces of northwest Wyoming as delineated by Reiners et al.

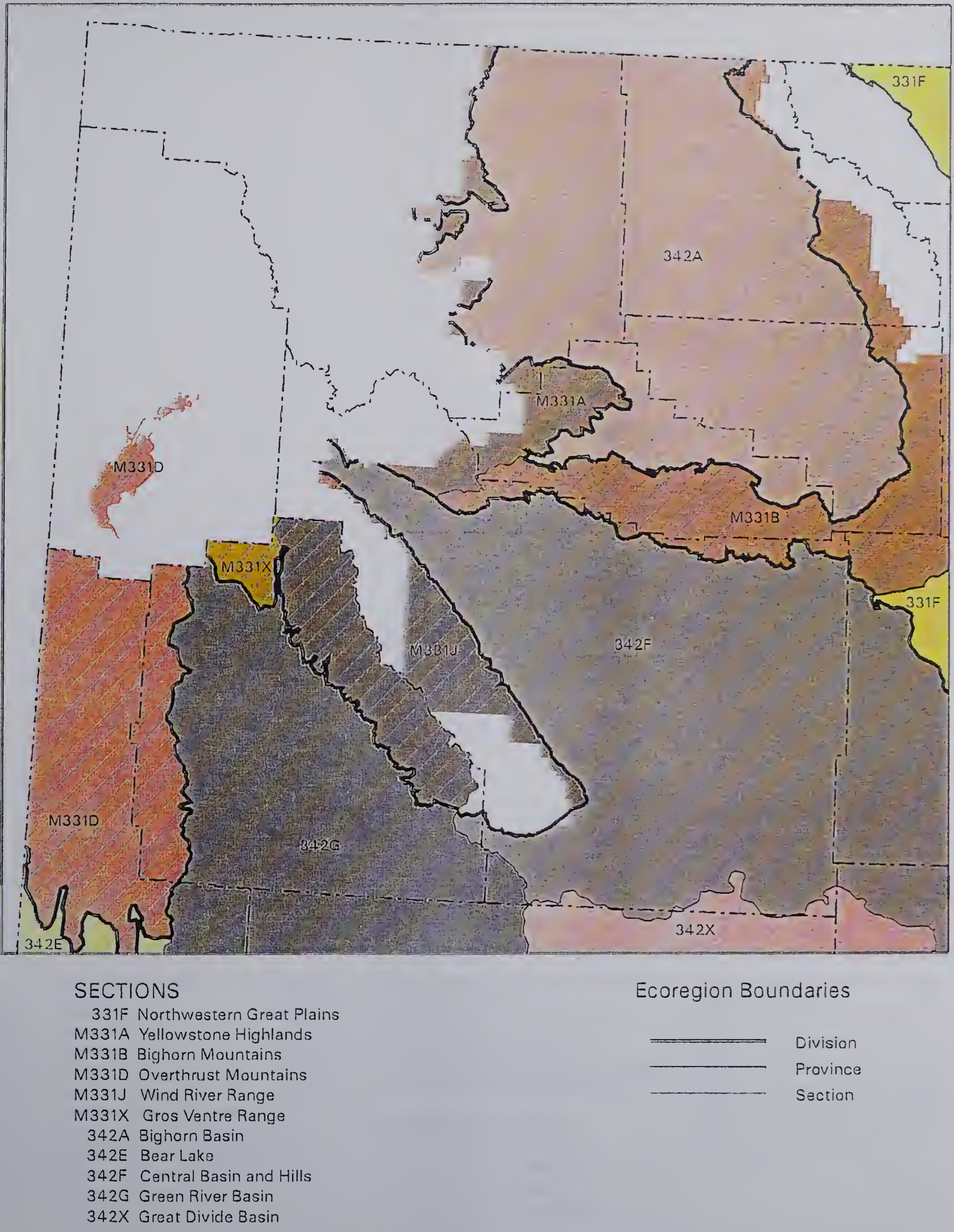


Fig. 25. Sections of northwest Wyoming as delineated by Reiners et al.

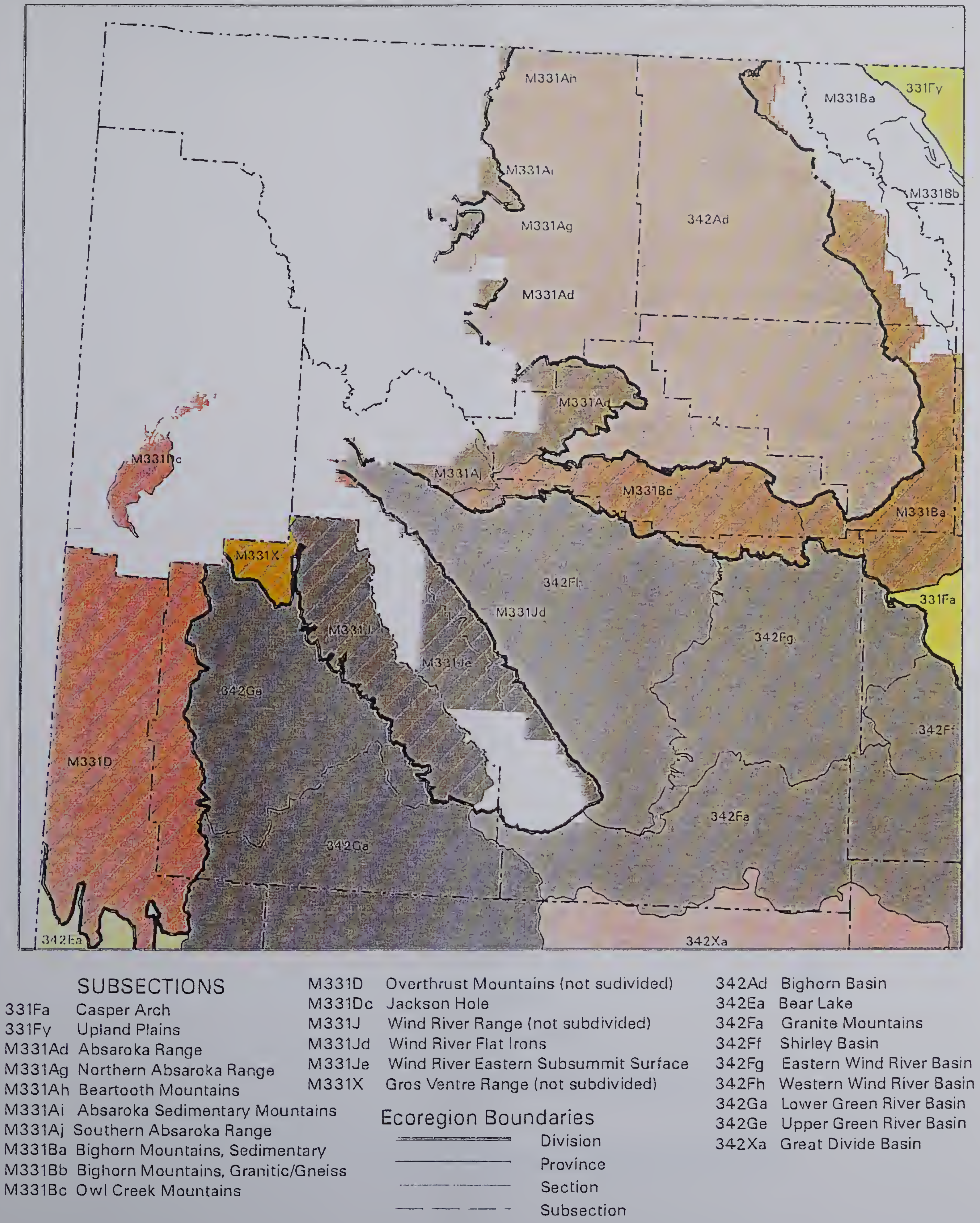

M331Ah
M331Ba
331Fy
M331Ai
M331Bb
M331Ag
342Ad
M331Ad
M331Ad
M331Dc
M331Aj
M331Bc
M331Ba
M331X
342Fh
M331Jd
331Fa
M331J
342Fg
M331Je
342Ge
342Ff
M331D
342Fa
342Ga
342Ea
342Xa
SUBSECTIONS
331Fa Casper Arch
331Fy Upland Plains
M331Ad Absaroka Range
M331Ag Northern Absaroka Range
M331Ah Beartooth Mountains
M331Ai Absaroka Sedimentary Mountains
M331Aj Southern Absaroka Range
M331Ba Bighorn Mountains, Sedimentary
M331Bb Bighorn Mountains, Granitic/Gneiss
M331Bc Owl Creek Mountains
M331D Overthrust Mountains (not sudivided)
M331Dc Jackson Hole
M331J Wind River Range (not subdivided)
M331Jd Wind River Flat Irons
M331Je Wind River Eastern Subsummit Surface
M331X Gros Ventre Range (not subdivided)
Ecoregion Boundaries
Division
Province
Section
Subsection
342Ad Bighorn Basin
342Ea Bear Lake
342Fa Granite Mountains
342Ff Shirley Basin
342Fg Eastern Wind River Basin
342Fh Western Wind River Basin
342Ga Lower Green River Basin
342Ge Upper Green River Basin
342Xa Great Divide Basin

Fig. 26. Subsections of northwest Wyoming as delineated by Reiners et al.

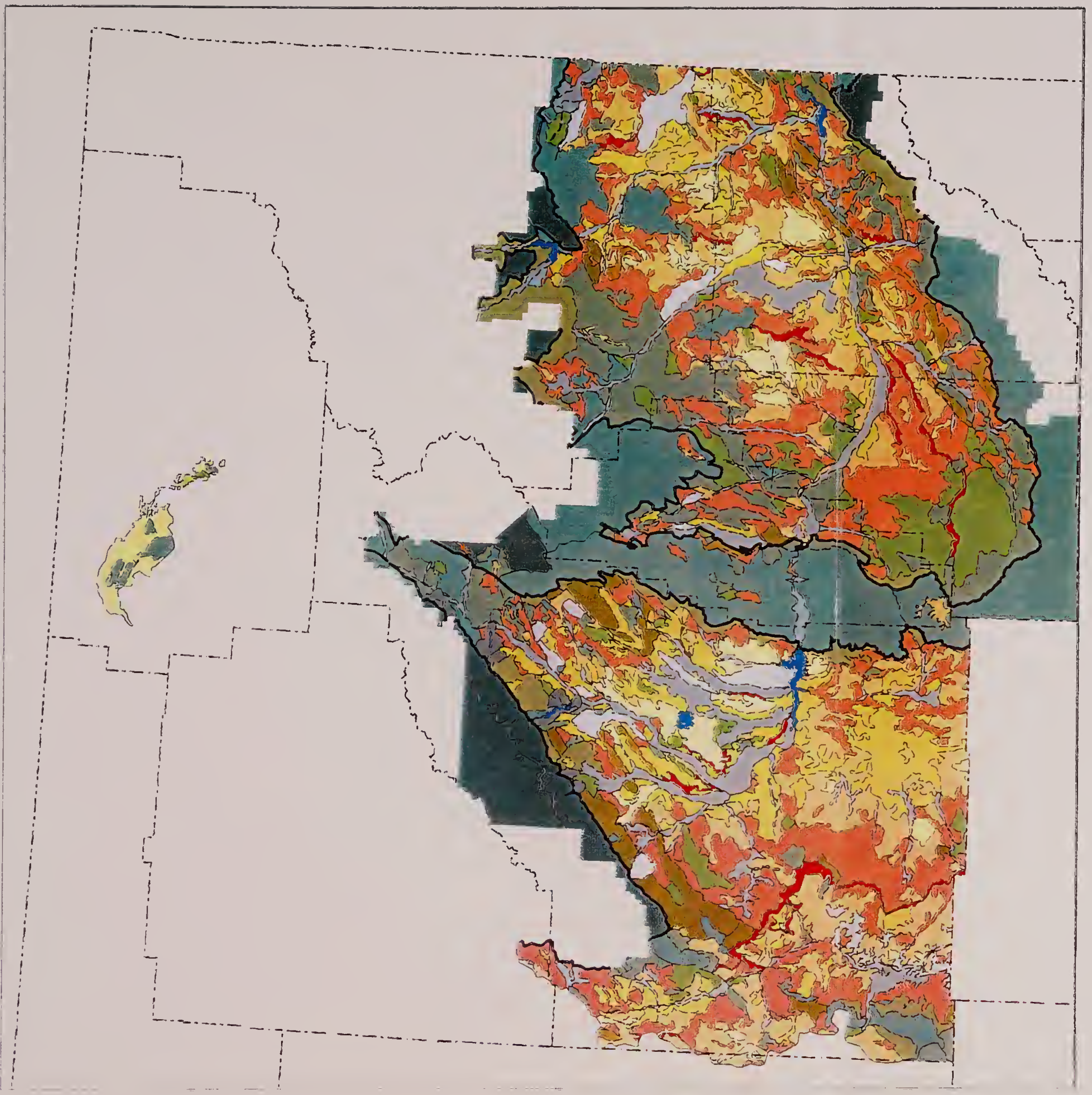
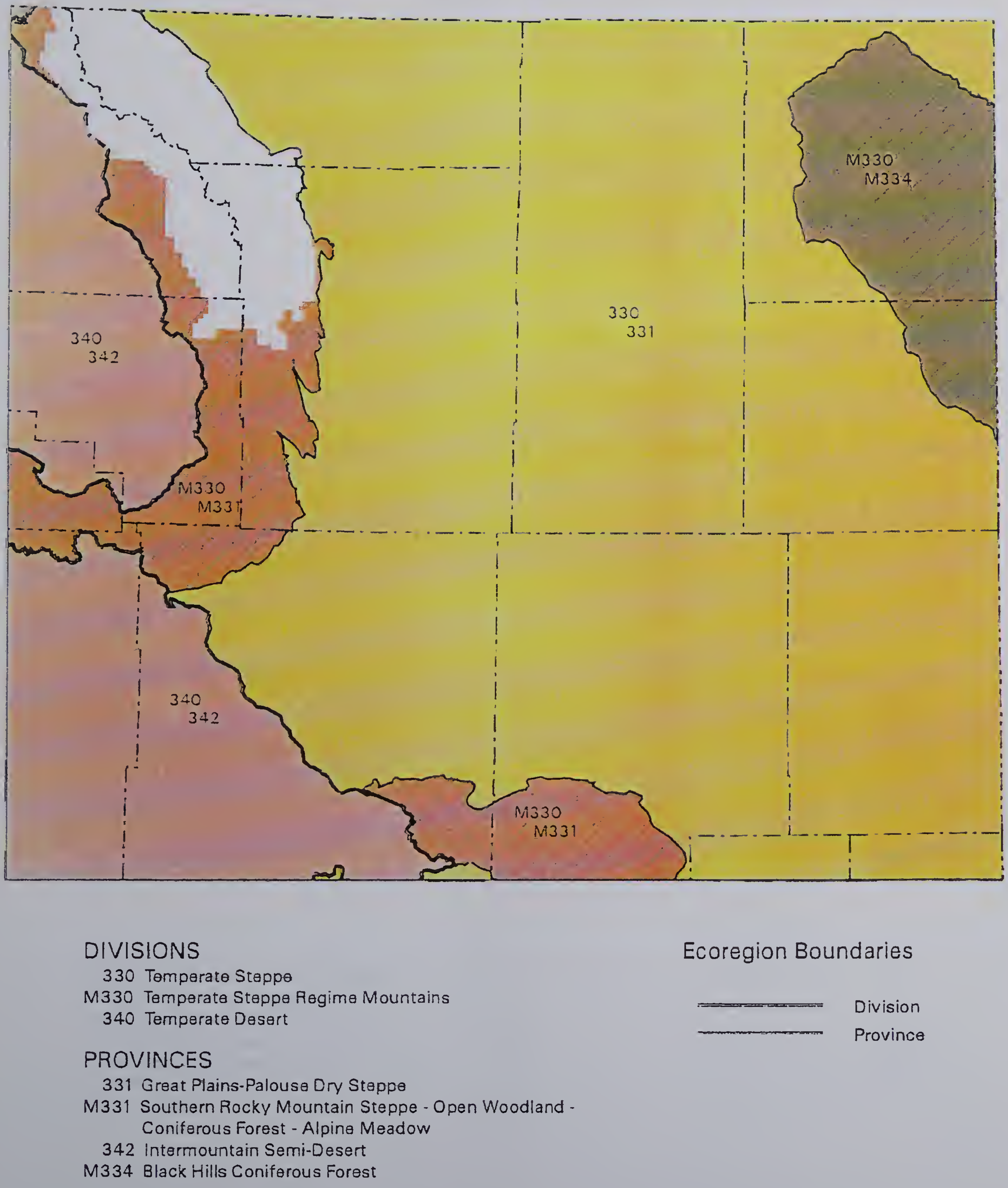


Fig. 27. Landtype Associations of northwest Wyoming as delineated by Reiners et al.


340
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M334
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M330
M331
DIVISIONS
330 Temperate Steppe
M330 Temperate Steppe Regime Mountains
340 Temperate Desert
PROVINCES
331 Great Plains-Palouse Dry Steppe
M331 Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow
342 Intermountain Semi-Desert
M334 Black Hills Coniferous Forest
Ecoregion Boundaries
Division
Province

Fig. 28. Divisions and Provinces of the Buffalo Resource Area as delineated by Reiners et al.

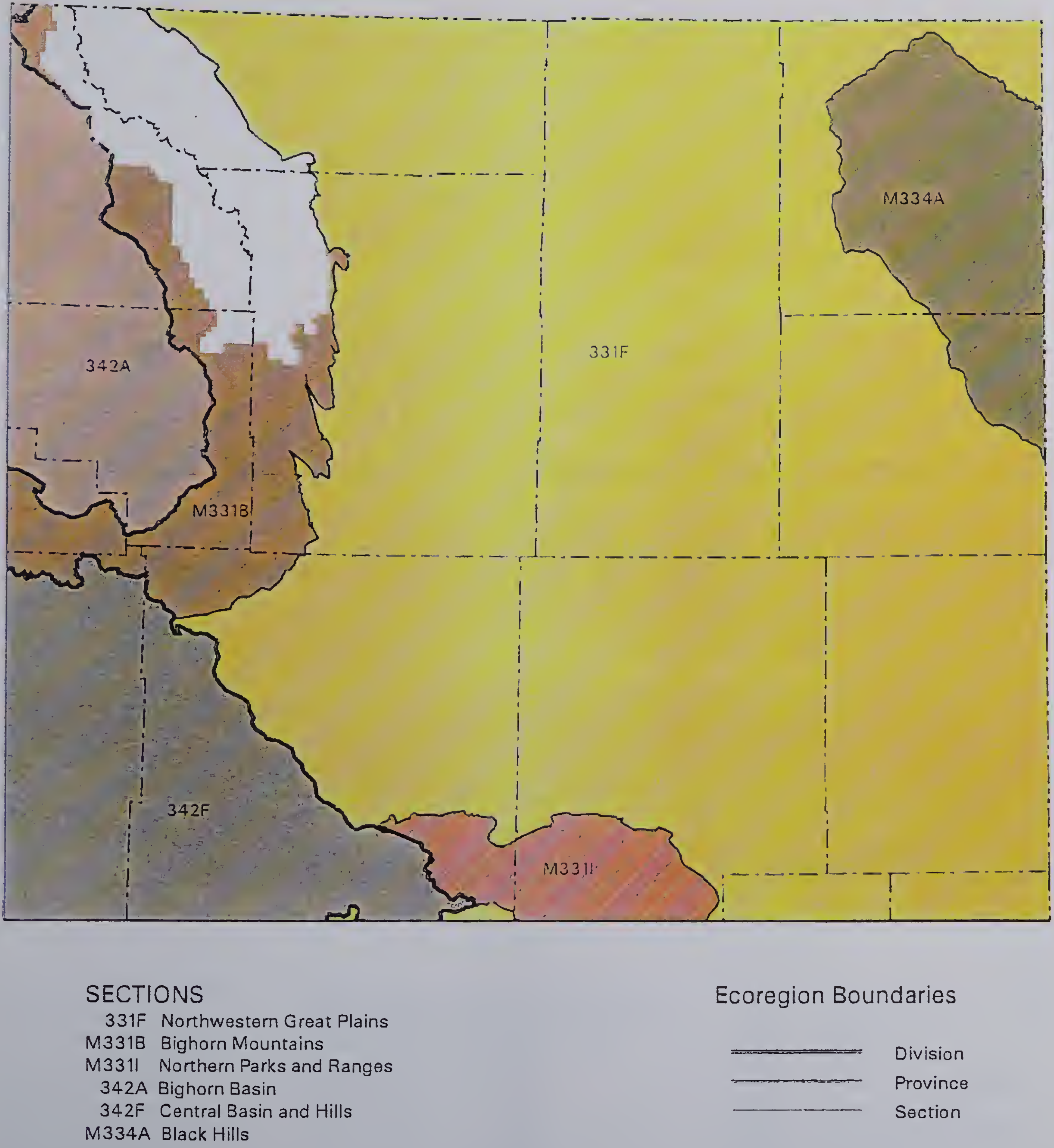

Fig. 29. Sections of the Buffalo Resource Area as delineated by Reiners et al.

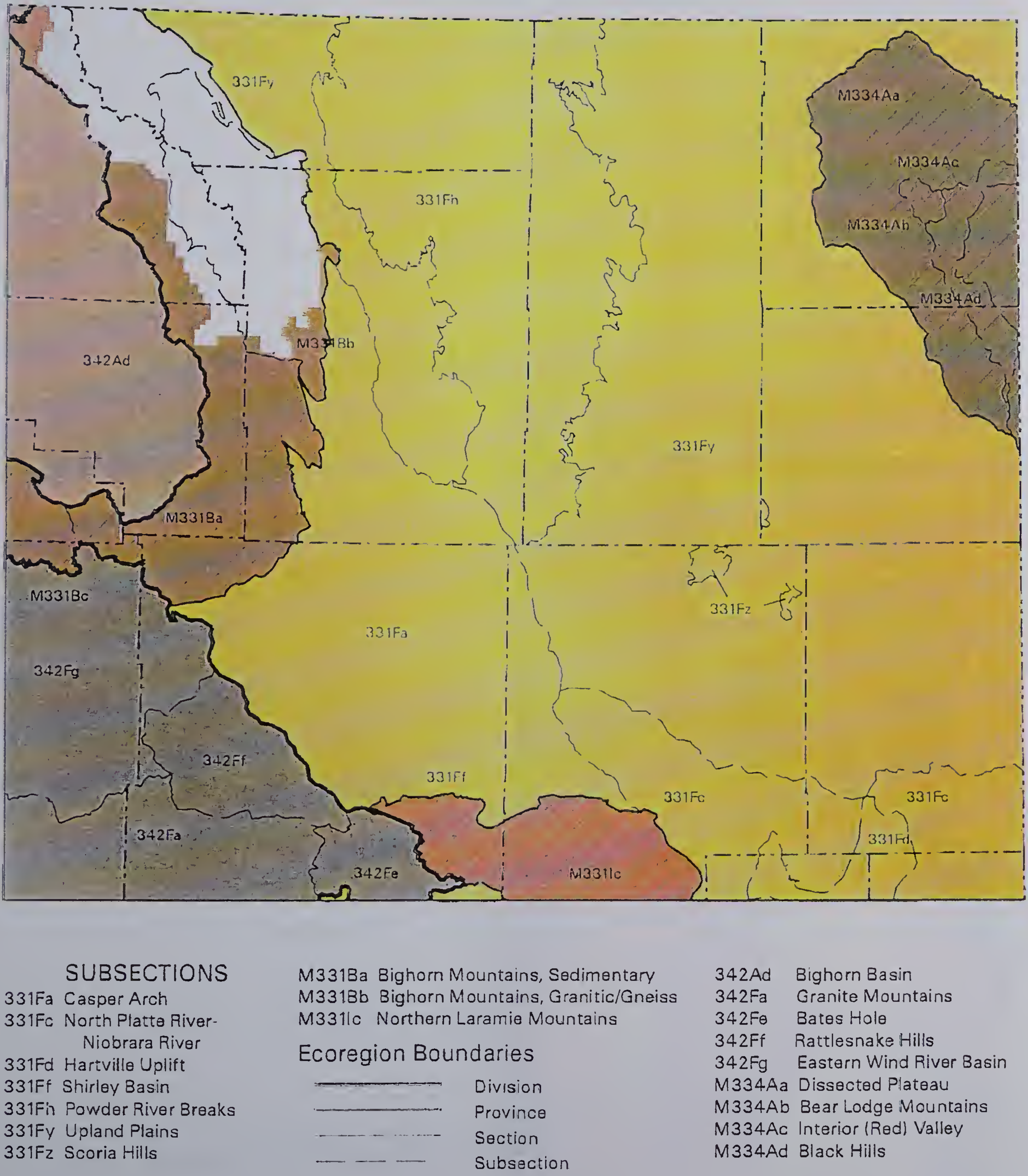

Fig. 30. Subsections of the Buffalo Resource Area as delineated by Reiners et al.

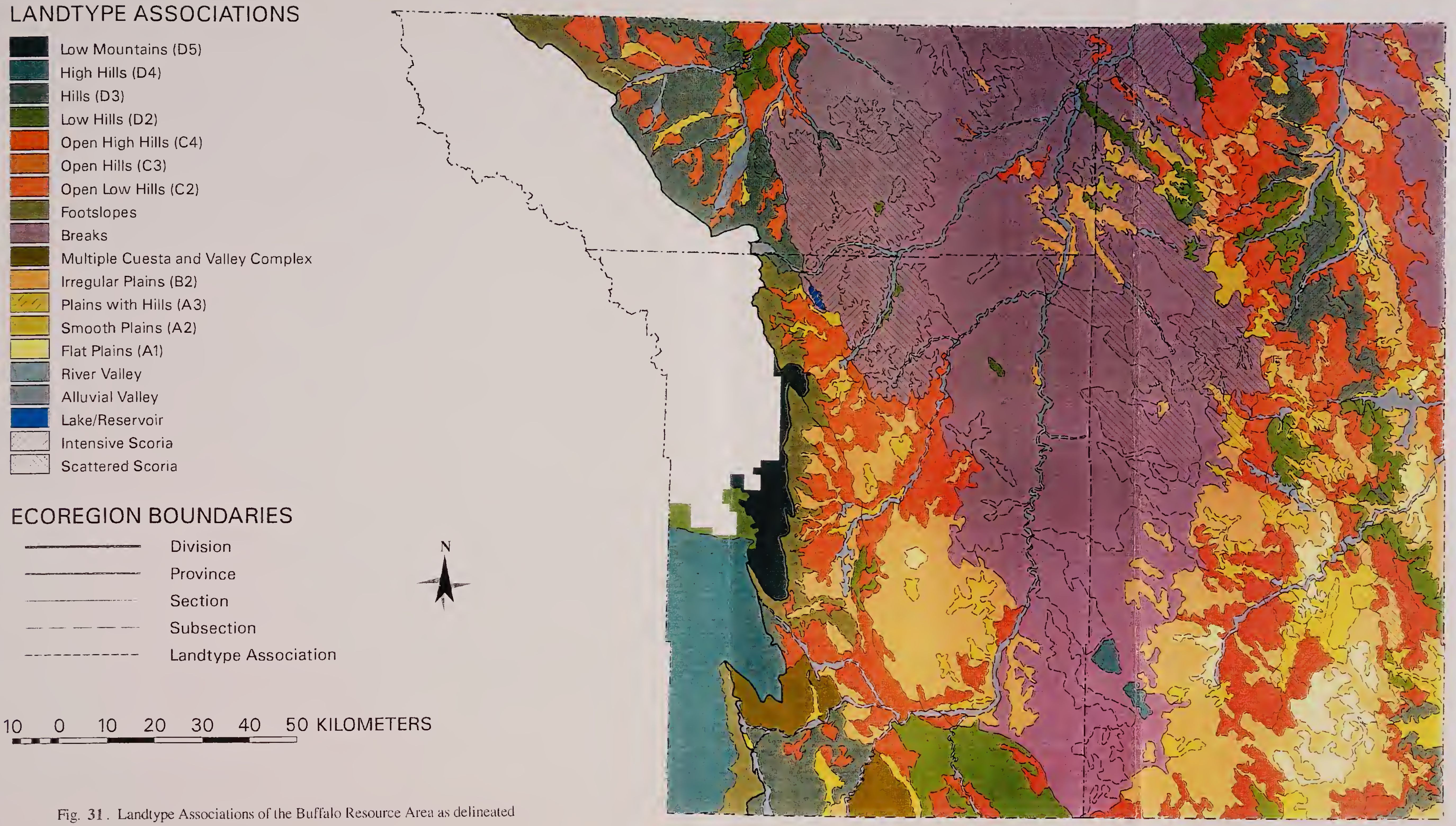

Fig. 31. Landtype Associations of the Buffalo Resource Area as delineated by Reiners et al.

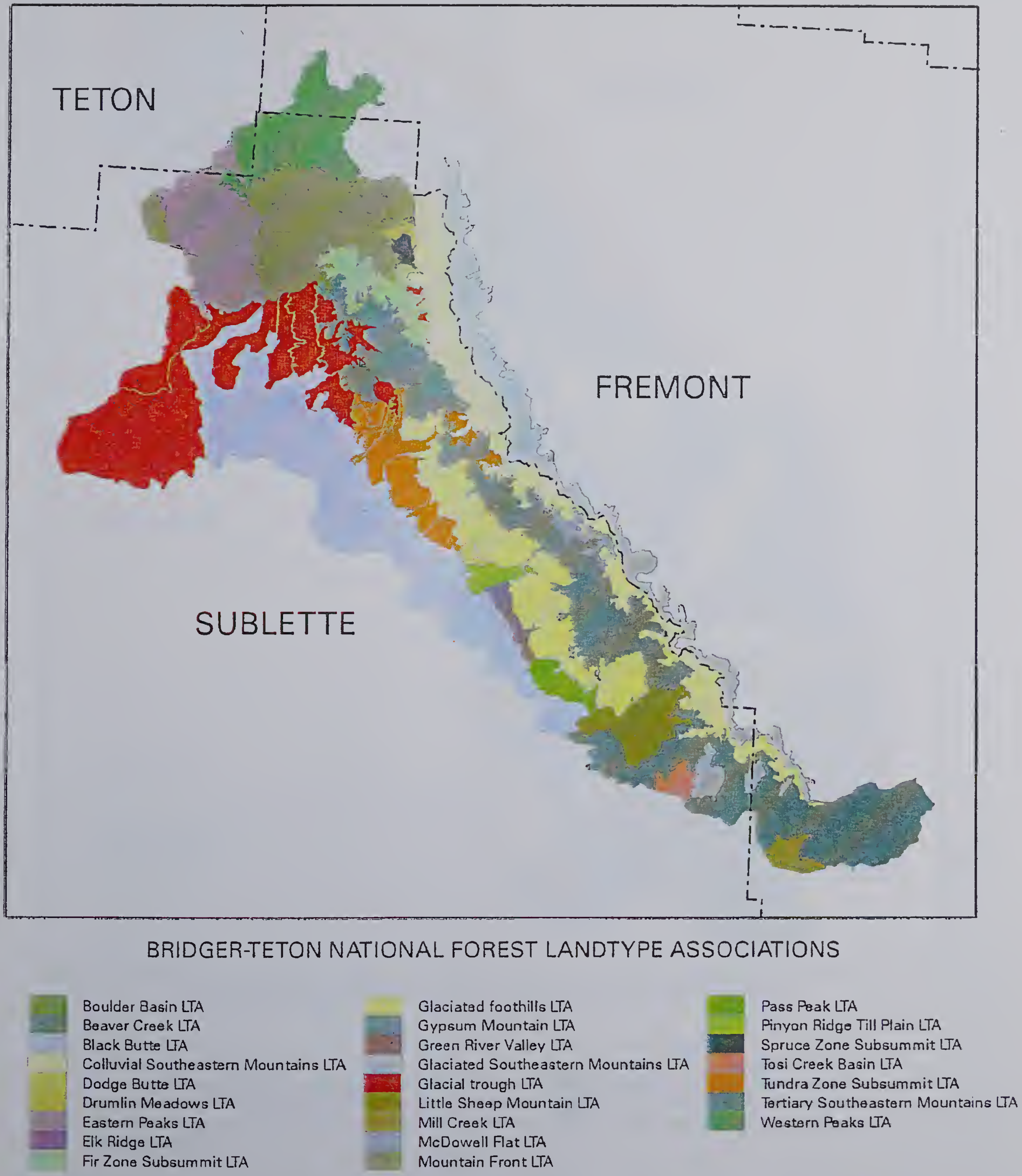

Fig. 32. Landtype Association boundaries for the Bridger–Teton National Forest (USDA – Forest Service, Bridger–Teton National Forest map). Table 8 of the Appendix provides a brief description of Landtype Associations. More detailed information can be found in Svalberg et al.(1997).

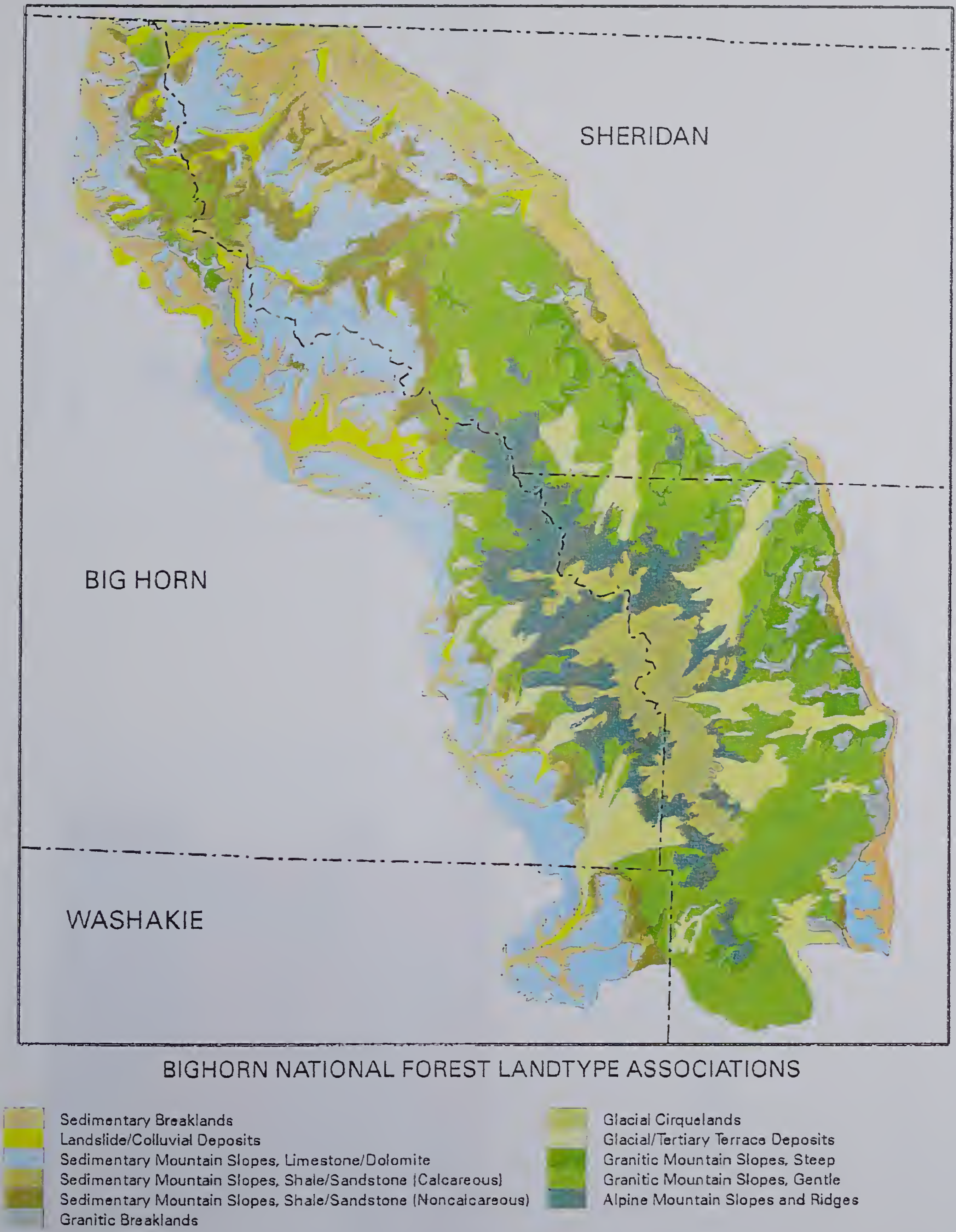
SHERIDAN
BIG HORN
WASHAKIE
BIGHORN NATIONAL FOREST LANDTYPE ASSOCIATIONS
Sedimentary Breaklands
Landslide/Colluvial Deposits
Sedimentary Mountain Slopes, Limestone/Dolomite
Sedimentary Mountain Slopes, Shale/Sandstone (Calcareous)
Sedimentary Mountain Slopes, Shale/Sandstone (Noncalcareous)
Granitic Breaklands
Glacial Cirquelands
Glacial/Tertiary Terrace Deposits
Granitic Mountain Slopes, Steep
Granitic Mountain Slopes, Gentle
Alpine Mountain Slopes and Ridges

Fig. 33. Landtype Association boundaries for the Bighorn National Forest (USDA – Forest Service, Bighorn National Forest map). Table 9 in the Appendix provides a detailed explanation of Landtype Associations.

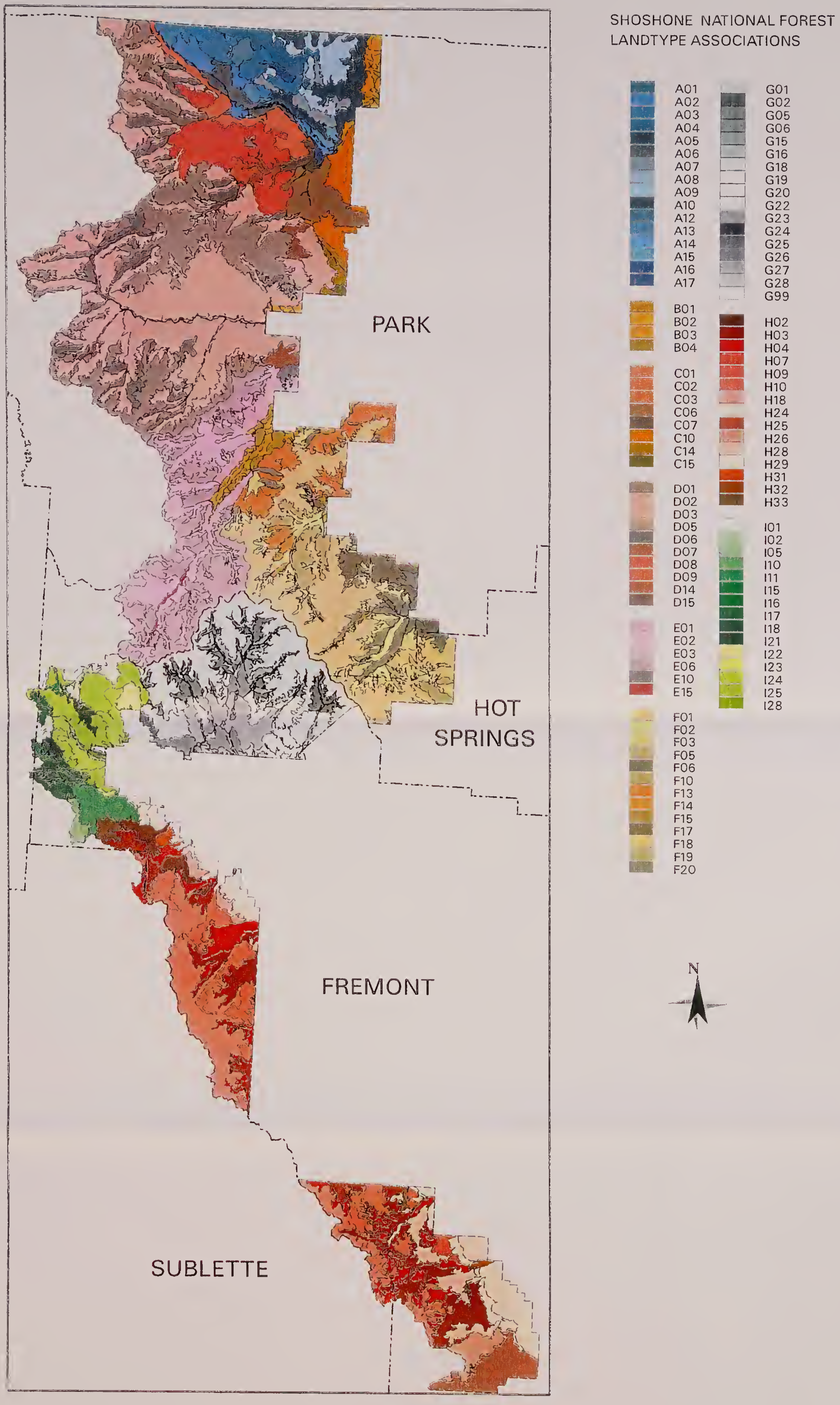

Fig. 34. Landtype Association boundaries for the Shoshone National Forest (USDA –Forest Service. Shoshone National Forest map). Table 10 of the Appendix provides Landtype Association names for the map unit codes.

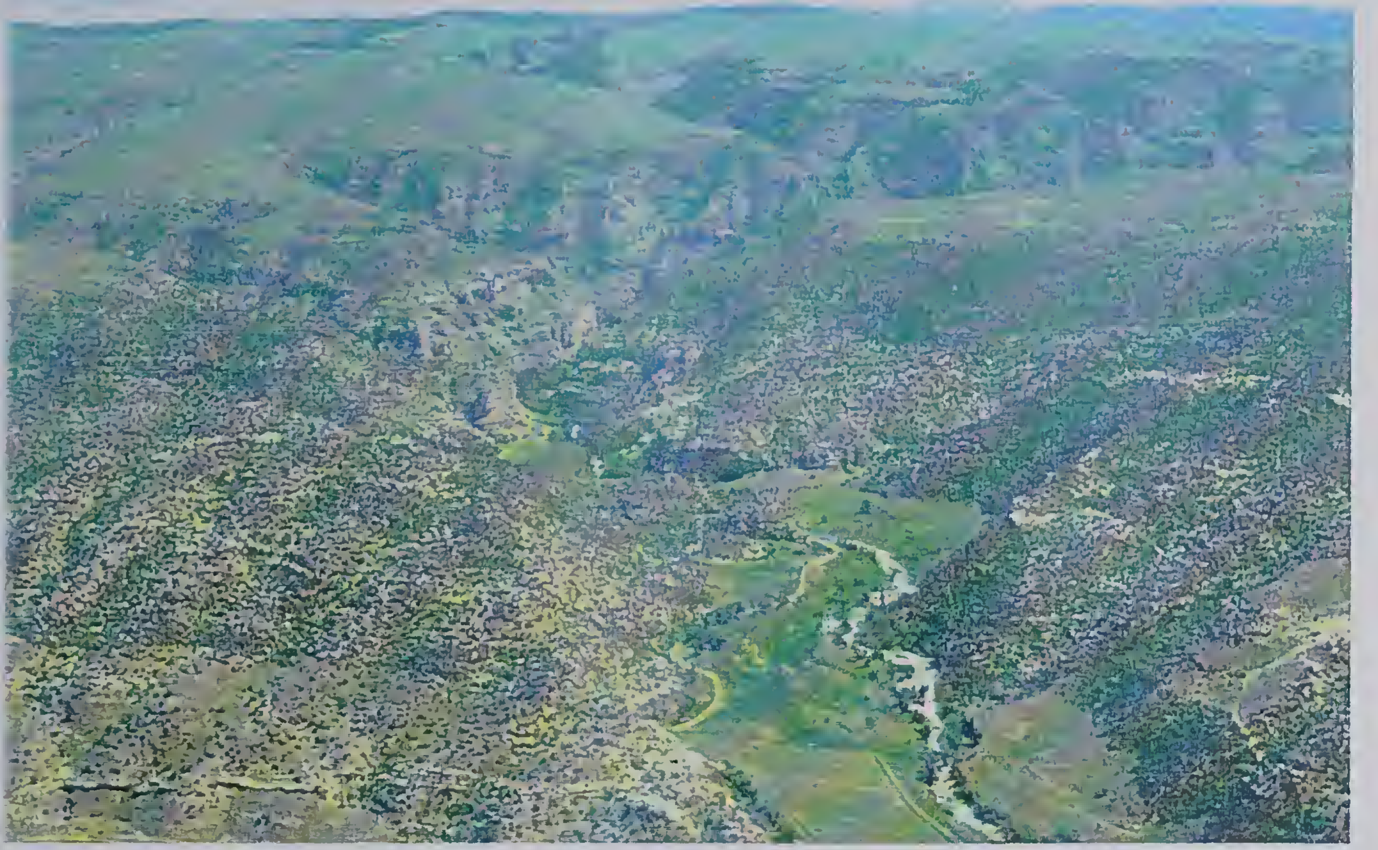

Figure 35. Aerial view east in Paintrock Canyon incised into the western slope of the Bighorn Mountains. Paintrock Creek in the foreground is in an "alluvial valley" (LTACODE 84), the dissected slope rising up to high peaks of the Bighorn Mountains is classified as "high hills" (LTACODE 14). This slope would be designated "footslopes" if the dissection were not so intense.

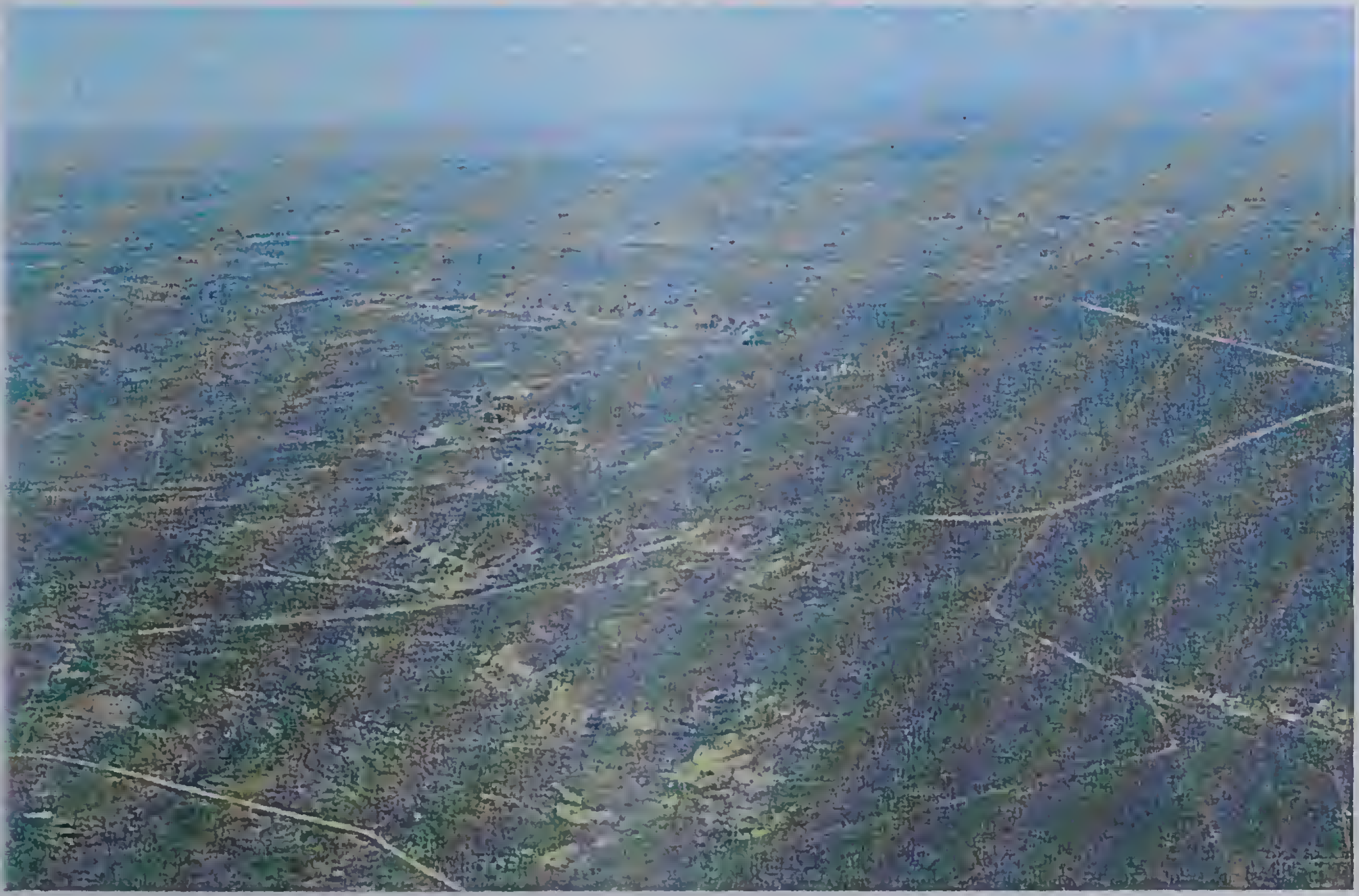

Figure 36. In this aerial view to the southwest, the very flat surface on the right is Polecat Bench, classified as a "mesa" (LTACODE 36). Polecat Bench breaks along a slight escarpment to a lower, somewhat rougher plain classified as a "smooth plain" (LTACODE 77). A "low hill" (LTACODE 12) can be seen in the right background.

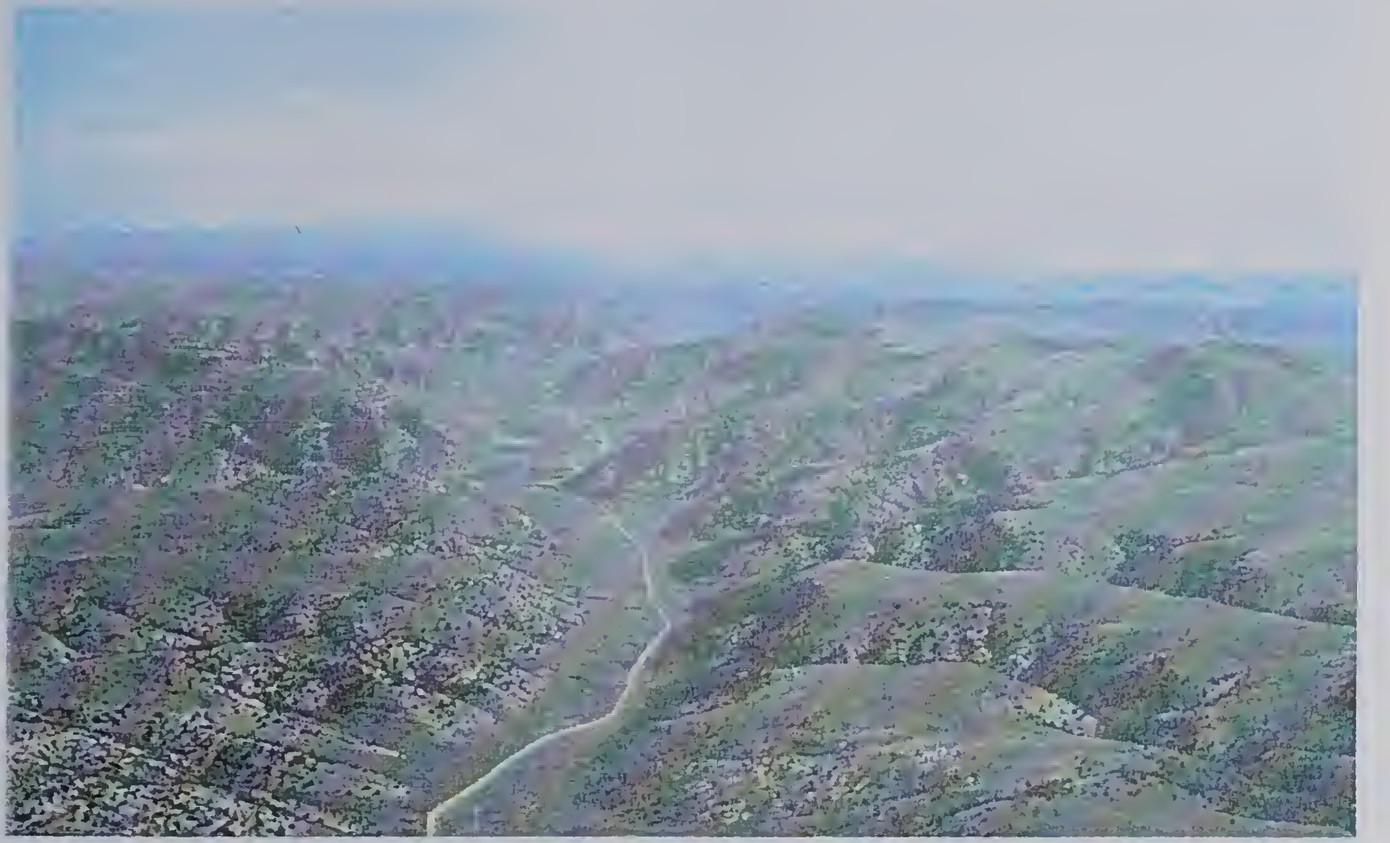

Figure 37. Aerial view to the east from the foothills of the southern Absaroka Mountains to the center of the Bighorn Basin. The valley bottom is classified as an "irregular plain" (LTACODE 79), the lower hills are classified as "open low hills" (LTACODE 62), and the larger hills to the upper left are classified as "high hills" (LTACODE 14).

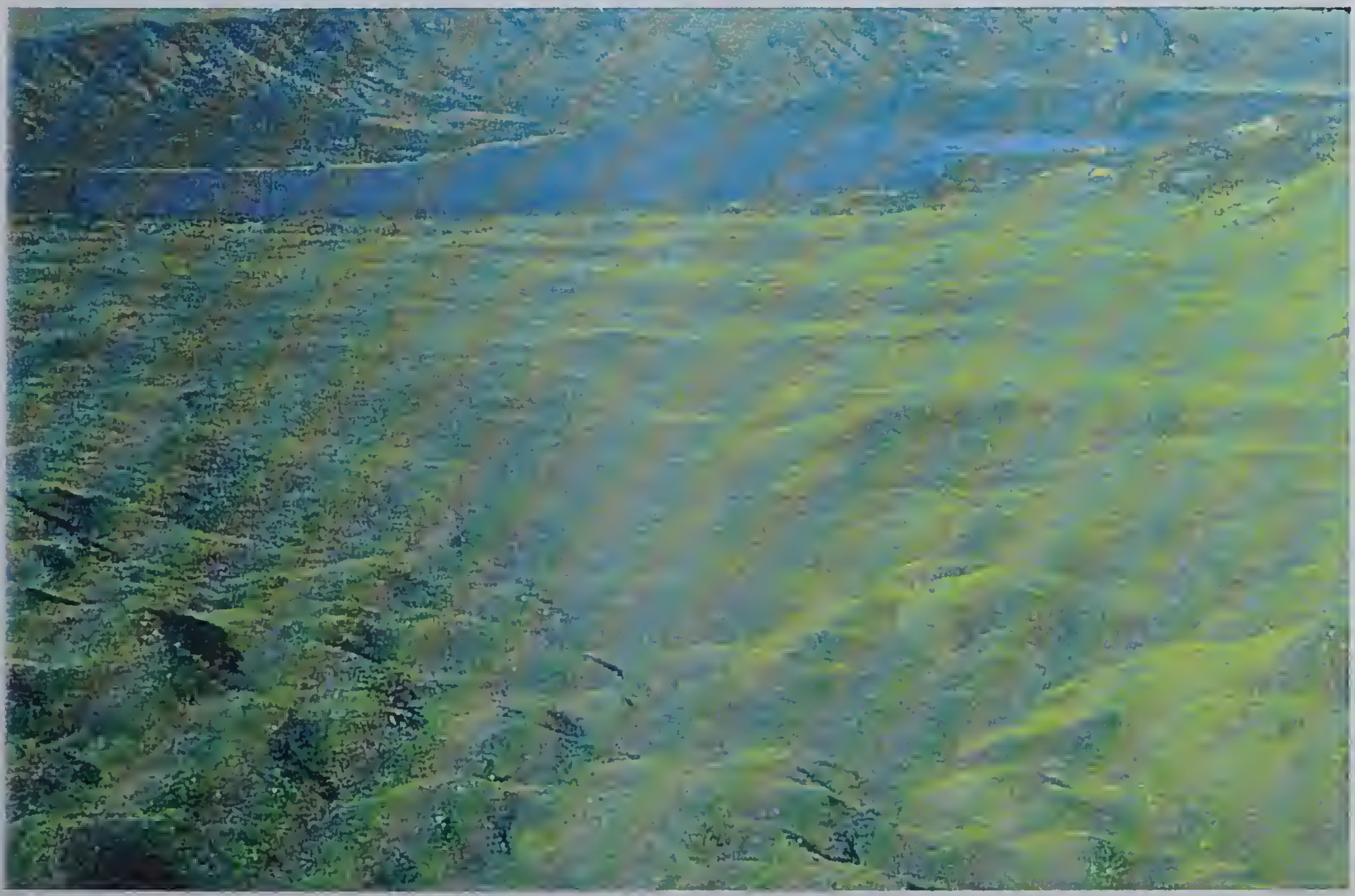

Figure 38. This aerial view to the southwest across Bull Lake on the east slope of the Wind River Range shows "glacial till and outwash hills" (LTACODE 61) surrounding Bull Lake itself, a "lake/reservoir" (LTACODE 83).

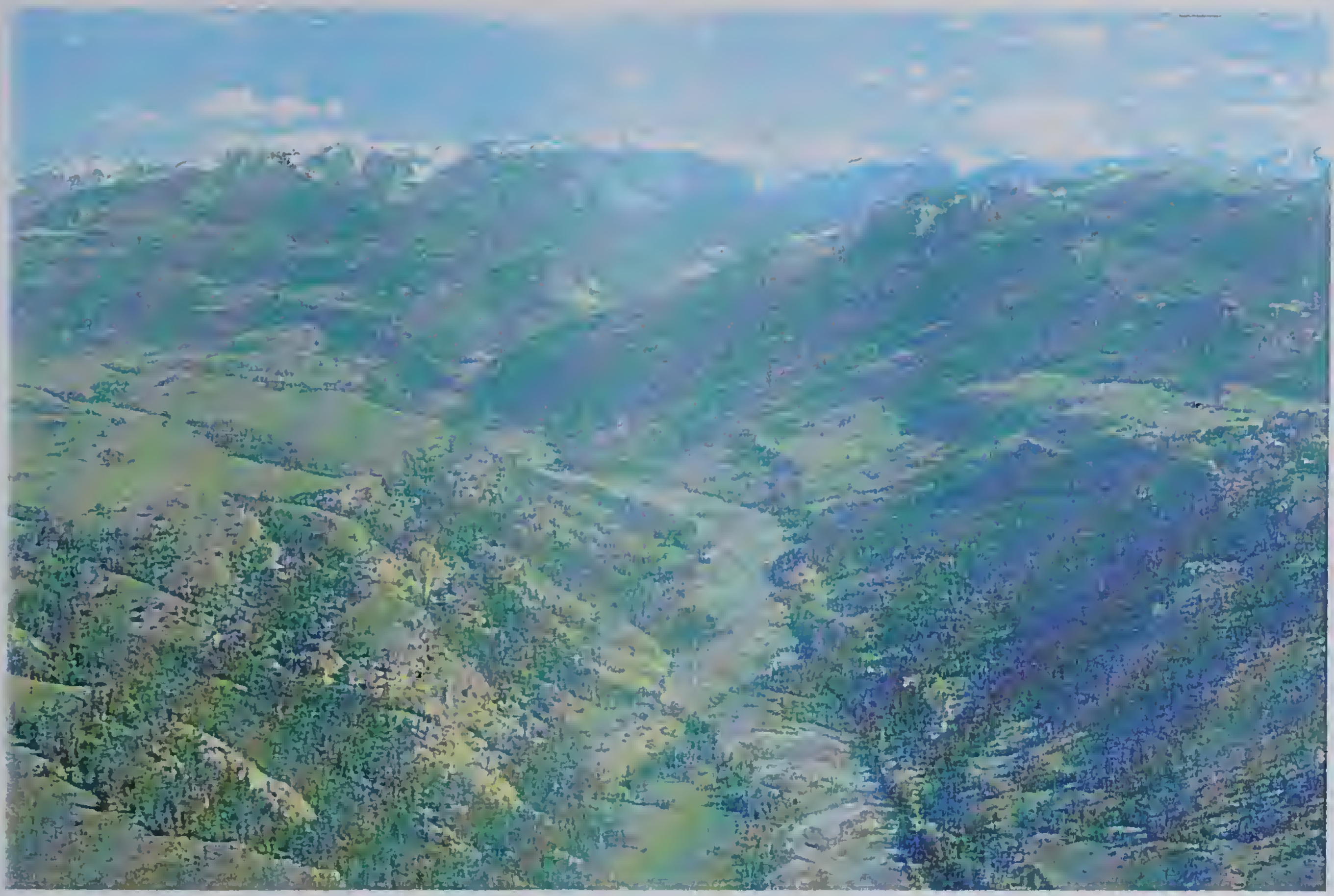

Figure 39. This aerial view is taken from the northern edge of the Wind River Basin looking up into the southern Absaroka Mountains. The stream is Wiggins Fork, the valley of which is an "alluvial valley" (LTACODE 84). The stream is surrounded by "high hills" (LTACODE 14) and "low mountains" (LTACODE 15) are seen in the background.

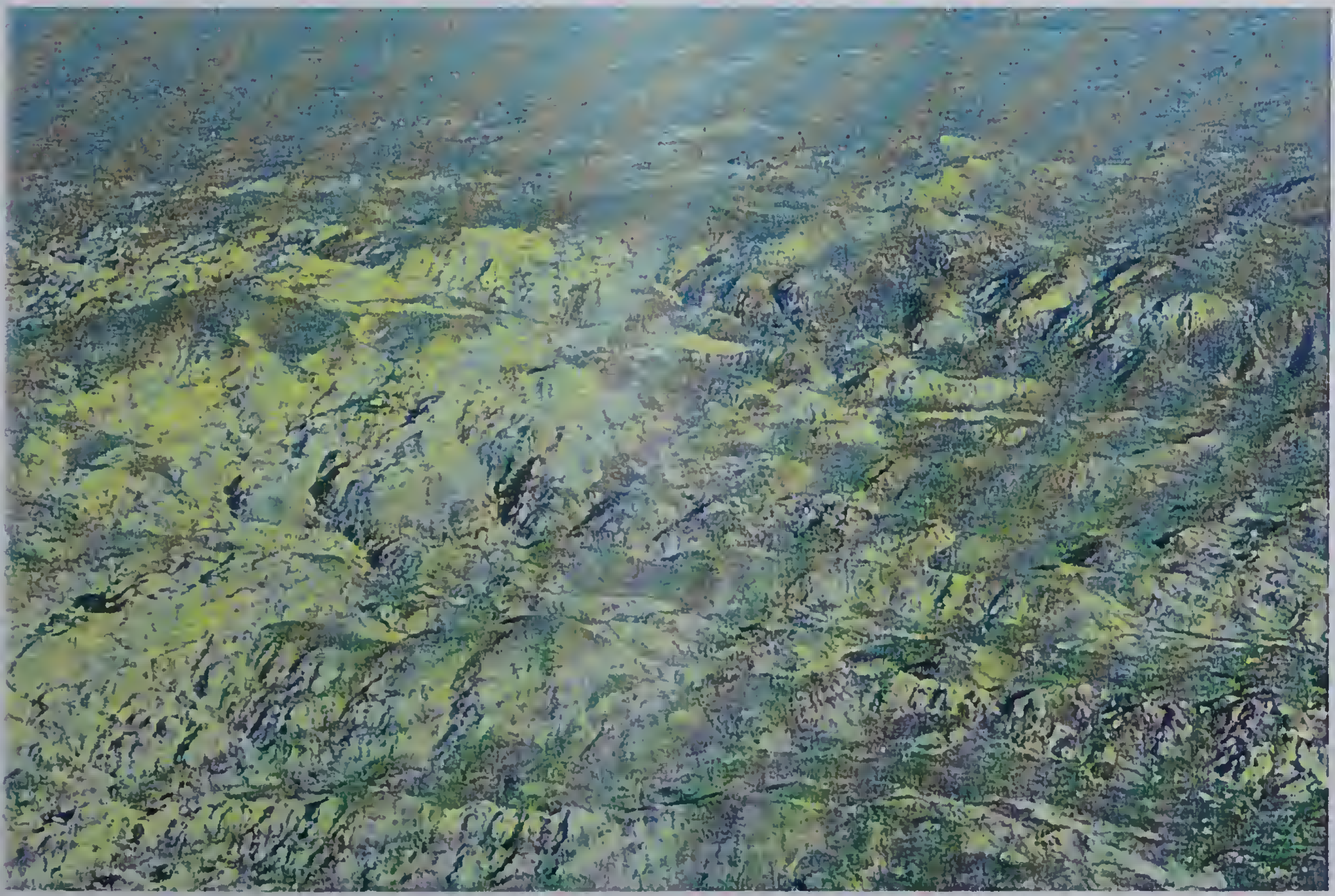

Figure 40. "Oil Mountain" is an erosional remnant lying just north of Beaver Rim and on the southern margin of the Western Wind River Basin Subsection. It is classified as a "hill" (LTACODE 13). At a smaller scale, the skirts of Oil Mountain could be described as "badlands."

Figure 41. "Beaver Rim" is a prominent "recessional escarpment" (LTACODE 41) extending across central Wyoming and demarcating the Granite Hills Subsection to the south (left of view) from the Western Wind River Basin Subsection to the north (right of view). The slopes below the escarpment are classified as "open low hills" (LTACODE 62); the relatively flat plain above the escarpment is classified as an "irregular plain" (LTACODE 79).

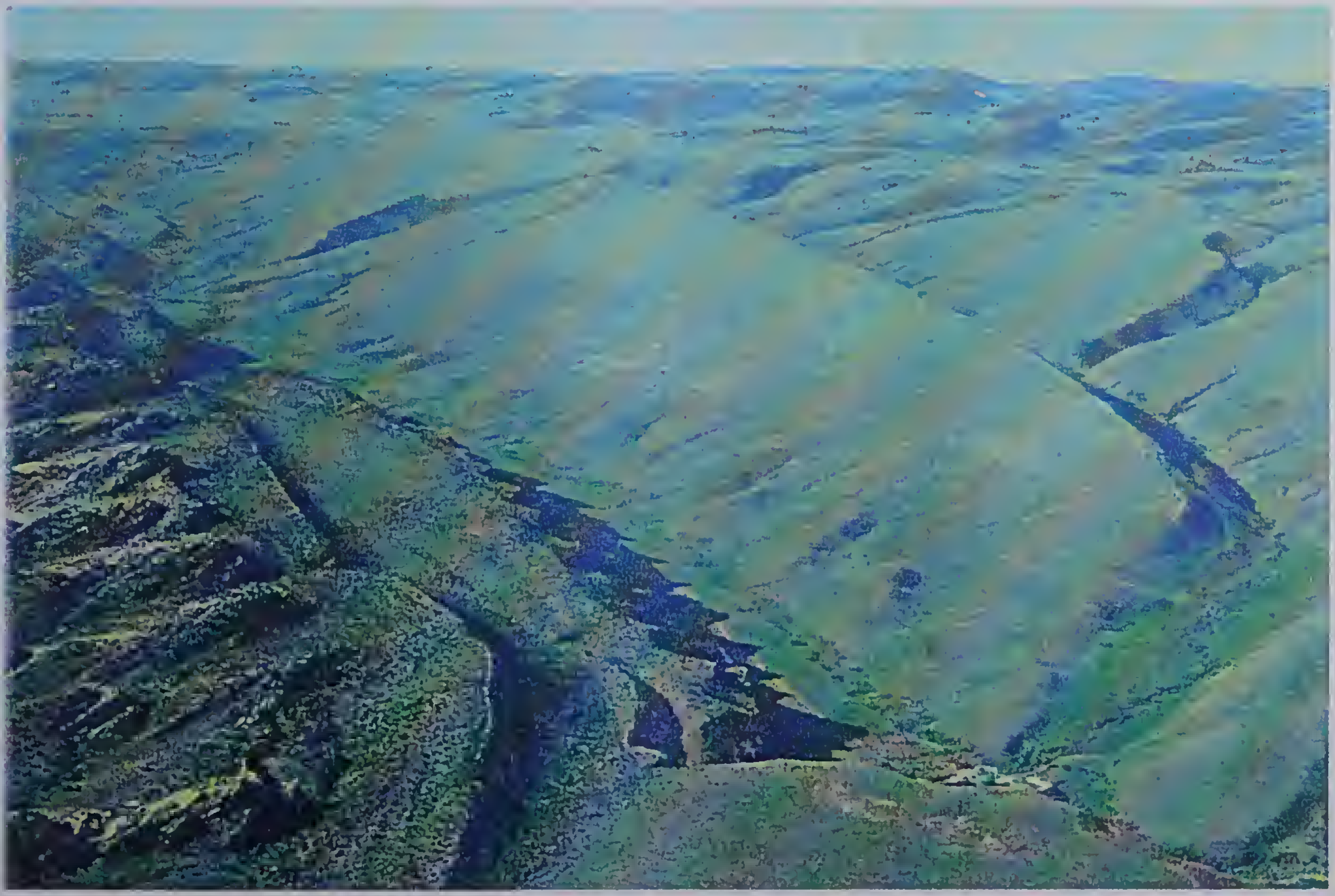

Figure 42. "Red Canyon," lying on the southeastern flank of the Wind River Range, is one of the more dramatic examples of the "multiple cuesta and valley complex" (LTACODE 51) that is so common across Wyoming.

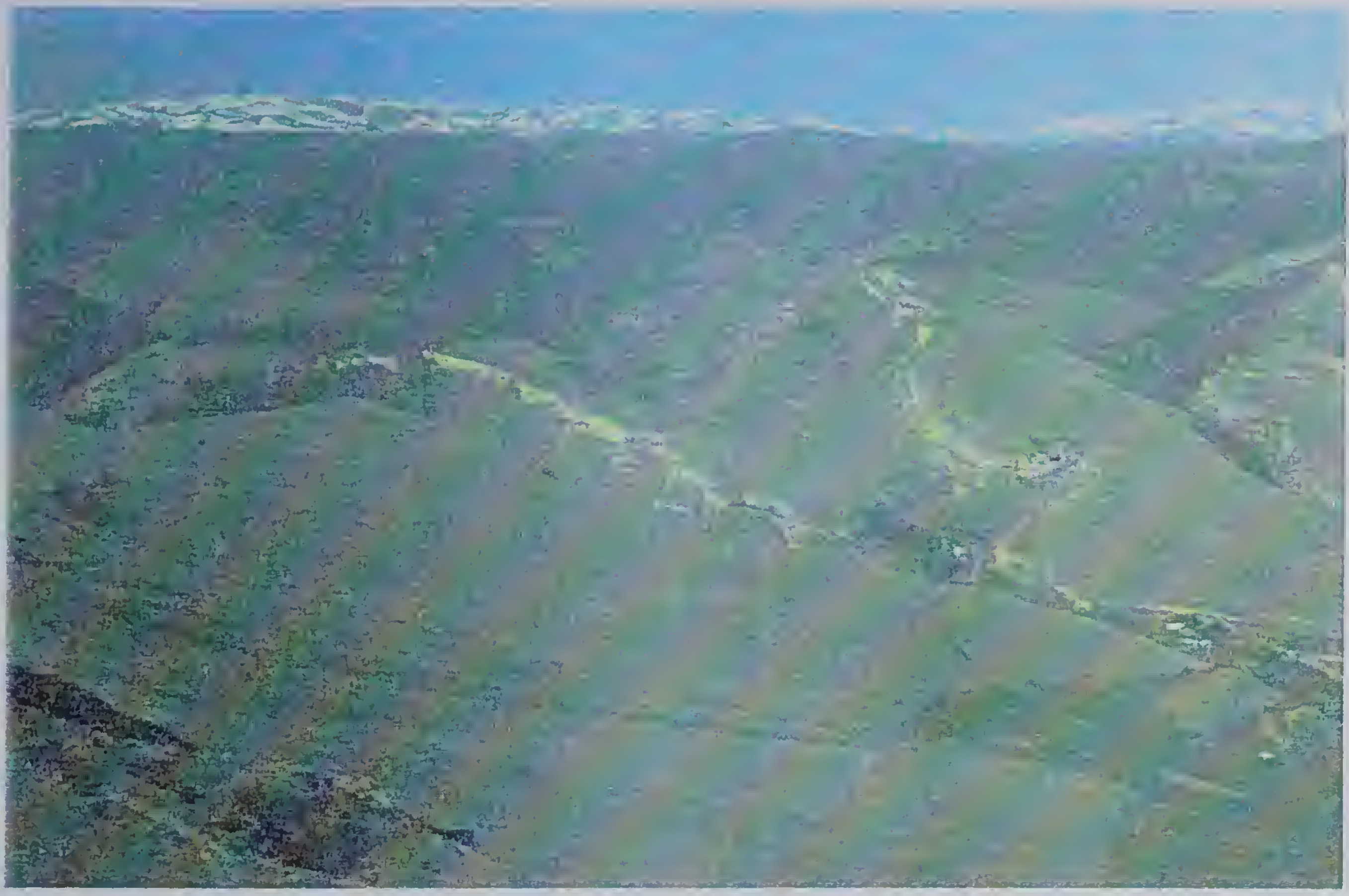

Figure 43. "Sinks Canyon," seen in this view to the southwest, is a deep incision through the flanking sedimentary rocks of the Wind River Range classified as the Wind River Range Flat Irons Subsection. At the far lower right hand corner, the Popo Agie River lies in an "alluvial valley" (LTACODE 84). The immediate foreground is primarily classified as "open low hills" (LTACODE 62), the flat-topped hill in the left foreground is classified as a "mesa" (LTACODE 36), the hills to the right of the river in the midground are classified as part of a "multiple cuesta and valley complex" (LTACODE 51), the forested slopes further into the background are classified as "low mountains" (LTACODE 15).

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Table 1. Areas of delineated land units in northwest Wyoming. Names of land units associated with hierarchical divisions above Landtype Association are presented in Section 4.

Division	Province	Section	Subsection	LTA	Landtype Association	#	km^2	Hectares	Acres
340	342	342A	342Ad	12	Low Hils	26	1668	166769	412086
				13	Hills	52	3107	310690	767716
				14	High Hills	15	939	93868	231947
				26	Footslopes	7	846	84646	209161
				36	Mesa	7	387	38734	195587
				41	Recessional Escarpment	11	304	30428	75187
				51	Multiple Cuesta Valley Complex	3	141	14127	34907
				52	Single Cuesta	9	286	28595	70657
				62	Open Low Hills	86	4422	442157	1092570
				63	Open Hills	5	78	7832	19353
				76	Flat Plains	12	536	53608	132466
				77	Smooth Plains	41	792	79153	195587
				79	Irregular Plains	71	3003	300309	742064
				83	Lake/Reservoir	2	56	5588	13808
				84	Alluvial Valley	34	1366	136641	337639
				85	River Valley	3	150	14998	37061
				92	Irregular Plains with Hills	1	12	1204	2975
		342F	342Fa	12	Low Hills	5	112	11185	27639
				13	Hills	11	167	16698	41260
				14	High Hills	5	221	22097	54603
				22	Granite Hills	10	188	18768	46375
				26	Footslopes	3	174	17437	43087
				41	Recessional Escarpment	4	45	4515	11156
				51	Multiple Cuesta Valley Complex	2	62	6244	15428
				52	Single Cuesta	1	19	1897	4688
				62	Open Low Hills	29	1282	128206	316796
				63	Open Hills	1	10	997	2462
				76	Flat Plains	6	84	8372	20688
				77	Smooth Plains	20	415	41511	102574
				79	Irregular Plains	27	1392	139210	343987
				84	Alluvial Valley	6	176	17587	43458
				85	River Valley	5	81	8140	20115
				86	Arroyo/Draw	1	22	2178	5383
			342Fg	12	Low Hills	2	54	5412	13372
				13	Hills	2	50	4953	12240
				26	Footslopes	3	98	9811	24243
				41	Recessional Escarpment	2	182	18180	44923
				51	Multiple Cuesta Valley Complex	3	74	7386	18250
				52	Single Cuesta	1	2	209	515
				62	Open Low Hills	14	1617	161686	399525
				76	Flat Plains	4	93	9288	22950
				77	Smooth Plains	15	1062	106221	262472
				79	Irregular Plains	26	1440	143981	355776
				84	Alluvial Valley	9	195	19455	48073
			342Fh	12	Low Hills	13	328	32753	80932
				13	Hills	23	515	51510	127281
				14	High Hills	14	469	46943	115996
				26	Footslopes	6	425	42460	104919
				36	Mesa	8	396	39624	97910
				41	Recessional Escarpment	5	93	9337	23072
				51	Multiple Cuesta Valley Complex	11	793	79274	195886
				52	Single Cuesta	2	63	6279	15515
				61	Glacial Till and Outwash Hills	10	207	20709	51172
				62	Open Low Hills	32	964	96441	238306

Table 1 (continued)

Division	Province	Section	Subsection	LTA	Landtype Association	#	km²	Hectares	Acres
340	342	342F	342Fh	63	Open Hills	1	22	2246	5550
				76	Flat Plains	6	535	53490	132175
				77	Smooth Plains	38	1046	104550	258343
				79	Irregular Plains	23	480	47985	118571
				83	Lake/Reservoir	4	118	11820	29207
				84	Alluvial Valley	18	1124	112382	277695
		342X	342Xa	13	Hills	2	76	7625	18843
M330	M331	M331A	M331Ad	14	High Hills	1	1086	108570	268276
				15	Low Mountains	9	100	10043	24816
				62	Open Low Hills	1	24	2366	5848
				79	Irregular Plains	1	7	681	1684
			M331Ag	15	Low Mountains	3	128	12789	31601
			M331Ah	14	High Hills	1	49	4864	12019
			M331Ai	15	Low Mountains	2	210	20988	51860
			M331Aj	13	Hills	2	36	3609	8917
				14	High Hills	2	44	4416	10913
				15	Low Mountains	1	249	24910	61554
				64	Open High Hills	1	6	586	1449
				92	Irregular Plains with Hills	1	6	618	1528
		M331B	M331Ba	14	High Hills	1	2263	226263	559095
				15	Low Mountains	7	205	20502	50661
				79	Irregular Plains	1	40	4006	9898
			M331Bc	12	Low Hills	2	22	2157	5330
				13	Hills	6	140	13959	34492
				14	High Hills	2	2223	222322	549357
				52	Single Cuesta	2	30	2982	7368
				62	Open Low Hills	5	63	6335	15654
				84	Alluvial Valley	2	13	1279	3159
				85	River Valley	1	49	4893	12090
		M331D	M331Dc	12	Low Hills	1	7	681	1682
				14	High Hills	4	111	11059	27327
				76	Flat Plains	2	310	31006	76615
				77	Smooth Plains	2	21	2115	5227
				91	Plains with Hills	1	2	211	521
			M331Dd	13	Hills	1	3	288	711
				14	High Hills	1	30	2982	7370
		M331J	M331Jc	13	Hills	2	7	680	1681
			M331Jd	15	Low Mountains	2	741	74103	183108
			M331Je	14	High Hills	2	29	2882	7122
				15	Low Mountains	3	798	79776	197127

Table 2. Areas of delineated land units in the Buffalo Resource Area. Names of land units associated with hierarchical divisions above Landtype Association are presented in Section 4.

Division	Province	Section	Subsection	LTA	Landtype Association	#	km^2	hectares	acres
330	331	331F	331Fa	12	Low Hills	4	445	44536	110048
				13	Hills	4	337	33694	83257
				26	Footslopes	1	261	26100	10563
				51	Multiple Cuesta Valley Complex	2	318	31814	12875
				62	Open Low Hills	20	627	62710	25379
				77	Smooth Plains	4	70	7032	2846
				79	Irregular Plains	10	263	26327	10655
				84	Alluvial Valley	5	92	9233	3737
				85	River Valley	3	43	4338	1756
				91	Plains with Hills	1	4	399	161
			331Fh	12	Low Hills	6	95	9469	3832
				13	Hills	2	15	1506	610
				14	High Hills	2	50	5050	2044
				35	Breaks	65	9186	918616	371764
				62	Open Low Hills	7	62	6227	2520
				63	Open Hills	1	4	364	147
				77	Smooth Plains	2	22	2234	904
				79	Irregular Plains	16	359	35944	14547
				83	Lake/Reservoir	1	8	823	333
				84	Alluvial Valley	20	242	24222	9803
				85	River Valley	6	38	3778	1529
			331Fy	12	Low Hills	30	789	78908	31934
				13	Hills	21	1299	129891	52567
				14	High Hills	1	0	5	2
				26	Footslopes	3	323	32340	13088
				35	Breaks	5	581	58120	23521
				62	Open Low Hills	113	4018	401797	162607
				63	Open Hills	2	6	617	250
				76	Flat Plains	12	487	48743	19726
				77	Smooth Plains	68	1241	124055	50205
				79	Irregular Plains	65	3343	334257	135274
				84	Alluvial Valley	47	507	50724	20528
				85	River Valley	8	49	4870	1971
M330	M331	M331B	M331Bb	12	Low Hills	1	81	8117	3285
				14	High Hills	1	987	98709	39948
				15	Low Mountains	1	275	27541	11146
				26	Footslopes	1	116	11556	4677

Table 3. Description of land cover types of northwest Wyoming and the Buffalo Resource Area derived from the Wyoming Gap Analysis Project (Merrill et al. 1996). The five-digit number is the code for the type used in the land cover coverage.

11001 Human settlements type

Towns and cities occupying greater than 100 hectares. Also can include residential areas on the outskirts of towns and cities. Often includes significant tree cover, especially by cottonwood species.

21001 Dry-land crops type

This type includes non-irrigated cropland, dryland improved pastures, fallow lands, rural development, ranch and farm facilities and shelter belts.

21002 Irrigated crops type

Any irrigated agricultural area. Includes most row crops, irrigated pastureland and hayfields and associated farm or ranch facilities and shelter belts.

31001 Mixed grass prairie type

This is a "catch-all" type for grasslands that contain a mixture of short grass and tall grass prairie species. These grasslands do not contain buffalo grass, considered an indicator of short grass prairie. Often occurs in patches intermixed with shrub species (i.e. *Artemisia tridentata*). When patchy, grass patches must occupy more than 50% of the landscape for the primary vegetation type to be classified as mixed grass. The vegetation may contain or be dominated by silver sagebrush. With the exception of silver sagebrush, trees or shrubs cannot occupy more than 25% of the total vegetative cover.

31002 Short grass prairie type

This graminoid type is dominated by short grass prairie species and buffalograss is considered an indicator. Buffalograss must be present for a grassland to be mapped as this type. This type usually consists of a short-grass understory of buffalograss and blue grama and an overstory of western wheatgrass, needle and thread grass or other mixed grass species. Total cover of trees or shrubs cannot exceed 25% of the total vegetative cover.

32001 Mesic upland shrub type

This is a "catch-all" class which includes a variety of shrub communities that grow in relatively mesic sites in Wyoming, often in snow catchments or downslope from catchments or in ravines over a wide range of elevation. Most often Rocky Mountain maple, bigtooth maple, serviceberry, snowberry, wax currant and/or chokecherry are dominant or co-dominant, but other shrub species can be present. Mountain mahogany species cannot be dominant. Mesic shrubs must comprise more than 25% of the total vegetative cover.

32002 Xeric upland shrub type

Table 3 (continued)

Shrub community with shrub cover dominated by species of mountain mahogany. Shrub species must comprise more than 25% of the total vegetative cover.

32005 Bitterbrush shrub steppe

Communities in which bitterbrush is the dominant or co-dominant shrub type, and in which shrubs comprise more than 25% of the total vegetative cover. Often *Artemisia tridentata* is co-dominant, but if there is a significant proportion of bitterbrush the community is classified as bitterbrush shrub steppe because of the importance of this type as a browse species.

32006 Mountain big sagebrush type

This shrub type is dominated by mountain big sagebrush. Often found with mixed grasses. Mountain big sagebrush must be the dominant shrub and total shrub cover must comprise more than 25% of the total vegetative cover. Sometimes occurs as patches of dense sagebrush with patches of mixed grasses. In this case, the sagebrush patches must comprise more than 50% of the total landscape area.

32007 Wyoming big sagebrush steppe type

This is a shrub steppe type with Wyoming big sagebrush the dominant shrub and with total shrub cover comprising more than 25% of the total vegetative cover. This type is variable in Wyoming and includes the full range from dense, homogeneous Wyoming big sagebrush to sparsely vegetated arid areas where Wyoming big sage is the dominant shrub. Often, patches of Wyoming big sagebrush are found with patches of mixed grasses. In these cases the type is classified as Wyoming big sagebrush steppe if the sagebrush patches occupy more than 50% of the total landscape area and as mixed grass if the grasses occupy more than 50% of the total area.

32008 Black sagebrush steppe type

Black sagebrush is the dominant shrub and total shrub cover comprises more than 25% of the total vegetative cover. Often mixed with grasses and with Wyoming big sagebrush.

32009 Big sagebrush shrubland type

Shrubland with basin big sagebrush dominating the shrub cover and total shrub cover comprising more than 25% of the total vegetative cover. Often mixed with grasses. When found in riparian areas, primary vegetation is classified as shrub riparian and secondary as big sagebrush shrubland.

32010 Desert shrub type

This type is a "catch-all" for a mixture of shrubs occurring in dry, saline habitats. Shrub cover is often dominated by *Atriplex confertifolia* but can be a mixture of Gardner's saltbush, black greasewood and/or desert cushion plants. When ground cover is pure *Atriplex gardneri* or pure *Sarcobatus vermiculatus* it is classified as such but when these species are mixed and dominance is unclear it is classified as desert shrub. This type also includes some cushion plant communities found in Wyoming basins. Total shrub cover must comprise more than 25% of the total vegetative cover.32011
Saltbush fans and flats type

Table 3 (continued)

Areas where Gardner's saltbush comprises more than 75% of the total vegetative cover. These relatively pure saltbush stands are often sparsely vegetated with bare soil constituting most of the land surface. Can be mixed with some grasses or other shrub species if these comprise less than 25% of total vegetative cover.

32012 Greasewood fans and flats type

Areas where greasewood comprises more than 75% of the total shrub cover and where shrubs comprise more than 25% of the total vegetative cover. Often mixed with grasses. Greasewood is frequently found in riparian areas and classified as shrub riparian with the greasewood type entered as a secondary vegetation type within the polygon.

32013 Sand dune complex type

This type includes stabilized sand dune communities. Most of the land surface is comprised of old dune deposits with dune stabilizing species such as Indian ricegrass, *Psoralea lanceolata*, and rabbitbrush present along with *Artemisia* species. Some patches of bare sand may be present but these do not dominate the landscape.

41001 Aspen forest type

Forest in which aspen dominates the canopy. Includes pure aspen forest and mixed conifer/aspen forest where aspen occupies more than 50% of the total canopy. Total canopy cover by trees must be greater than 25%.

42001 Spruce-fir intact type

Spruce-fir forest not significantly affected by logging. Engelmann spruce and/or subalpine fir must be dominant or co-dominant in the canopy and total canopy coverage by all tree species must be greater than 25%.

42003 Douglas fir type

Forest or woodland in which the canopy is dominated by Douglas fir. This type includes both intact Douglas fir forest and Douglas fir forest influenced by logging (when contiguous logged areas are smaller than 100 ha). Total forest cover must be greater than 25%.

42004 Lodgepole pine closed forest type

Forest in which lodgepole pine dominates the canopy and with a canopy closure greater than 25%. Engelmann spruce and subalpine fir may be mixed with the canopy trees or important in the understory, but cannot be the dominant canopy tree type. Can include dog-hair lodgepole stands. Logging activity is not significant in this type. (Logged conifer is a separate class).

42007 Logged conifer

Areas within conifer forest that are significantly affected by logging. This type consists of clearcut areas within a matrix of conifer forests and as such is a mosaic of standing forest and logged areas with logged areas covering more than 40% of

Table 3 (continued)

the total ground area. The logged areas may be in early successional stages but are not classified as forest or woodland until regrowing trees achieve 25% canopy closure.

42008 Whitebark Pine type

Found in the western mountain ranges of Wyoming, including the Wind Rivers, Teton, Absaroka, Gros Ventre, Owl Creek and Washakie ranges. Tends to occur on dry sites near timberline and in the subalpine. Rare at the lower end of its elevation range.

42009 Limber pine woodland and scrub type

Forest or woodland dominated by limber pine. This type includes the range of types from closed canopy forest dominated by limber pine to open limber pine woodland where trees constitute more than 25% of total vegetative cover. Often co-occurs with juniper woodland and/or with shrubs or grasses in the understory.

42010 Ponderosa pine type

Forest in which ponderosa pine dominates the canopy and in which total canopy closure is greater than 25%. If logged, this type becomes part of the logged conifer type.

42015 Juniper woodland type

Woodland dominated by species of juniper. Woodland species must comprise more than 25% of the total vegetative cover. This type includes pinon-juniper woodlands as well as pure juniper woodlands. Often occurs with mountain mahogany species, big sagebrush and/or limber pine.

52001 Open water type

Any area of open water with area greater than 40 hectares. Includes lakes and reservoirs. Rivers are classified as one of the three riparian types and are not included in this type.

61001 Forest dominated riparian type

Riparian zones in which tree species dominate the vegetation of the riparian corridor. In Wyoming, these are usually cottonwood species, but can also be aspen, boxelder, or a variety of conifer species. Trees must occupy more than 25% of the vegetative cover within the riparian zone.

62001 Shrub dominated riparian type

Riparian zones where shrubs comprise more than 25% of the vegetative cover and where trees occupy less than 25% of the total vegetative cover. Shrubs often include willow species, *Artemisia* species and/or greasewood but other shrubs (e.g. hawthorn, wild plum, birch, alder, tamarisk, shrubby cinquefoil) may be present or dominant. Includes alpine riparian zones dominated by *Salix* species or other shrubs.

Table 3 (continued)

62002 Graminoid and forb dominated wetland type

This type includes any non-riverine wetland with vegetation dominated by grasses or forbs. Trees or shrubs cannot occupy more than 25% of the total vegetative cover. Includes communities such as wet and moist meadow grasslands, marsh and swamp wetlands, cattail, bullrush and sedge dominated wetlands and inland saltgrass/alkali sacaton dominated wetlands. Includes both low and high salinity wetlands. Low salinity wetlands are characterized by *Typha* spp., *Juncus balticus, Carex* spp., and *Spartina pectinatus*. High salinity wetlands are characterized by *Sporobolus airoides, Spartina gracilis, Distichlis stricta, Suaeda depressa, Elymus* spp. and *Agropyron* ssp.

62003 Graminoid and forb dominated riparian type

Any riverine wetland with vegetation dominated by graminoids or forbs. Must not have more than 25% shrub or tree cover.

71001 Unvegetated playa type

This type includes bare saline playa areas, mud flats, shorelines, sand beaches and gravel bars. Very sparse, salt-tolerant vegetation such as *Salicornia rubra* may be present around margins. Total vegetative cover is less than 10%.

73001 Active Sand Dune type

This type includes unvegetated sand dunes where vegetative cover is less than 10%. Sand is often actively redistributed by wind.

74001 Basin bare rock and soil type

This basin type includes naturally occurring areas of bare rock and soil such as cliffs, spires, rock outcrops and talus fields as well as steep scarps of soft rock with total vegetative cover less than 15%.

74002 Alpine bare rock and soil type

Areas of bare rock or soil including cliffs, spires, and talus fields occurring in the mountain ranges of Wyoming.

75001 Mining operations (and other bare ground disturbance) type

This type includes active and unreclaimed mine sites, strip mines, associated development, drainage ponds, etc., and areas of oil and gas development where the vegetation has been removed or damaged over areas larger than 100 hectares.

82001 Meadow tundra type

This type includes graminoid and forb dominated vegetation that occurs above treeline in the alpine zone. Common species include bent grasses, sheep fescue, icegrass, alpine mosses, lichen, silene, avens, sundivort and forget-me-not. Trees or shrubs cannot occupy more than 25% of the total vegetative cover.

Table 3 (continued)

82002	Subalpine meadow type

Graminoid and forb dominated type occurring within and below upper treeline. Often found in mountain park situations. Trees or shrubs cannot occupy more than 25% of the total vegetative cover.

Table 4. Explanation of codes for geologic units of northwest Wyoming and the Buffalo Resource Area derived from the digital geologic map of Wyoming (Green and Drouillard 1994, Love and Christiansen 1985).

Geology Code	Explanation
Cr	CAMBRIAN ROCKS (SOUTH) GALLATIN LIMESTONE, GROS VENTRE FORMATION AND EQUIVALENTS, AND FLATHEAD SANDSTONE (NORTH)
Jsg	SUNDANCE AND GYPSUM SPRING FORMATIONS
JTr	SUNDANCE AND GYPSUM SPRING FORMATION AND NUGGET SANDSTONE
JTrgn	GYPSUM SPRING FORMATION AND NUGGET SANDSTONE -- Wind River Basin
JTrn	NUGGET SANDSTONE
Kb	BACON RIDGE SANDSTONE
Kc	CODY SHALE
Kf	FRONTIER FORMATION
Kfb	FOX HILLS SANDSTONE AND BEARPAW SHALE
Kfh	FOX HILLS SANDSTONE
Kfl	FOX HILLS SANDSTONE AND LEWIS SHALE
Kft	FRONTIER FORMATION AND MOWRY AND THERMOPOLIS SHALES
KJ	CLOVERLY AND MORRISON FORMATIONS
KJg	CLOVERLY, MORRISON, SUNDANCE AND GYPSUM SPRING FORMATION
KJs	CLOVERLY, MORRISON, AND SUNDANCE FORMATIONS--Includes wedge edge of Nugget Sandstone in T. 34 N., R. 88 W., and T. 32 N., R. 91 W.
Kl	LANCE FORMATION
Kle	LEWIS SHALE
Klm	LANCE FORMATION, FOX HILLS SANDSTONE, MEETEETSE FORMATION, AND BEARPAW AND LEWIS SHALES--In the Bighorn Basin consists of Lance, Meeteetse, and, in the southeastern part, tongue of Lewis Shale; in the northern part of the Wind River Basin, of Lance, Meeteetse, and Lewis, and, in the southeastern part of the basin, of Lance and Lewis; on the west side of the Powder River Basin north of T. 45 N., of Lance, Fox Hills, and Bearpaw, and, to the south, of Lance, Fox Hills, and Lewis
Km	MEETEETSE FORMATION
Kmt	MOWRY AND THERMOPOLIS SHALES
Kmv	MESAVERDE FORMATION OR GROUP--On Rawlins uplift includes Almond Formation, Pine Ridge Sandstone, Allen Ridge Formation, and Haystack Mountains Formation. In Laramie Basin includes Pine Ridge Sandstone and Rock River Formation
Kp	PIERRE SHALE
Kso	SOHARE FORMATION
KTr	CLOVERLY, MORRISON, SUNDANCE, AND GYPSUM SPRING FORMATIONS AND NUGGET SANDSTONE
MD	MADISON LIMESTONE AND DARBY FORMATION
MDO	MADISON LIMESTONE, DARBY OR THREE FORKS, JEFFERSON AND BEARTOOTH BUTTE FORMATIONS, AND BIGHORN DOLOMITE--Darby on west flank of Washakie Range; Beartooth Butte only in Beartooth Mountains
Mm	MADISON LIMESTONE OR GROUP--Includes wedge edge of Bighorn Dolomite in Tps. 43 and 44 N., Rgs. 85 and 86 W.
MzPz	MESOZOIC AND PALEOZOIC ROCKS--Shown in small areas of complex structure South side of Granite Mountains north of Green Mountain--Nugget Sandstone, Chugwater and Goose Egg Formations, Tensleep Sand-

Table 4 (continued)

	stone, and Amsden Formation (Jurassic? through Upper Mississippian) South flank of Ferris Mountains--Nugget Sandstone and Chugwater and Goose Egg Formations (Jurassic? through Permian) Northeast flank of Seminoe Mountains--Cloverly, Morrison, Sundance, Chugwater, and Goose Egg Formations (Lower Cretaceous through Permian) West flank of Sierra Madre--Chugwater, Goose Egg, Casper, and Fountain Formations (Upper Triassic through Middle Pennsylvanian) East flank of Laramie Mountains--Cloverly, Morrison, Sundance, Chugwater, and Goose Egg Formations, and, east of fault in T. 19 N., Casper Formation (Lower Cretaceous through Middle Pennsylvanian) East flank of Bighorn Mountains--Cloverly, Morrison, Sundance, Gypsum Spring, Chugwater, and Goose Egg Formations (Lower Cretaceous through Permian)
OC	BIGHORN DOLOMITE, SNOWY RANGE FORMATION, PILGRIM LIMESTONE, PARK SHALE, MEAGHER LIMESTONE, WOLSEY SHALE, AND FLATHEAD SANDSTONE (NORTHWEST) WHITEWOOD DOLOMITE, AND WINNEPEG AND DEADWOOD FORMATIONS (NORTHEAST)
PM	TENSLEEP SANDSTONE AND AMSDEN FORMATION
Pp	PHOSPHORIA FORMATION AND RELATED ROCKS--Intertonguing equivalents of parts of Phosphoria are Park City Formation and Shedhorn Sandstone
Pzr	MADISON LIMESTONE AND CAMBRIAN ROCKS (SOUTH) MADISON LIMESTONE, DARBY FORMATION, BIGHORN DOLOMITE, GALLATIN LIMESTONE, GROS VENTRE FORMATION, AND FLATHEAD SANDSTONE (NORTH) East of Wind River Canyon consists of Madison, Bighorn, and Cambrian rocks; in Rattlesnake Hills, east end of Granite Mountains, and north end of Laramie Mountains consists of Madison Limestone and Cambrian rocks
Qa	ALLUVIUM AND COLLUVIUM
Qg	GLACIAL DEPOSITS
Ql	PLAYA LAKE AND OTHER LACUSTRINE DEPOSITS
Qls	LANDSLIDE DEPOSITS
Qs	DUNE SAND AND LOESS
Qt	GRAVEL, PEDIMENT, AND FAN DEPOSITS--May include some glacial deposits and Tertiary gravels
QTc	CONGLOMERATE (PLEISTOCENE TO MIOCENE)
Qu	UNDIVIDED SURFICIAL DEPOSITS
Ta	THOROFARE CREEK GROUP--AYCROSS FORMATION
Tb	BRIDGER FORMATION
Tbs	BATTLE SPRING FORMATION
Tbw	TRANSITIONAL UNIT BETWEEN BATTLE SPRING AND WASATCH FORMATIONS
Tcg	CROOKS GAP CONGLOMERATE
Teml	MIDDLE AND LOWER EOCENE ROCKS --Equivalent to Aycross and Wind River Formations
Tfl	LEBO MEMBER OF FORT UNION FORMATION
Tflt	LEBO AND TULLOCK MEMBER OF FORT UNION FORMATION
Tft	TULLOCK MEMBER OF FORT UNION FORMATION
Tftl	TONGUE RIVER AND LEBO MEMBERS OF FORT UNION FORMATION
Tftr	TONGUE RIVER MEMBER OF FORT UNION FORMATION
Tfu	FORT UNION FORMATION
Tgl	LANEY MEMBER OF GREEN RIVER FORMATION
Tim	INDIAN MEADOWS FORMATION
Tip	ICE POINT CONGLOMERATE
Tm	MIOCENE ROCKS
Tmu	UPPER MIOCENE ROCKS
Toe	OLIGOCENE AND (OR) UPPER AND MIDDLE EOCENE ROCKS
Trc	CHUGWATER FORMATION OR GROUP--Includes overlying Jelm Formation

Table 4 (continued)

Geology Code	Explanation
	in Shirley and Seminoe Mountains and at northern end of Laramie Basin
Trcd	CHUGWATER AND DINWOODY FORMATIONS
TrPcg	CHUGWATER AND GOOSE EGG FORMATIONS
TrPg	GOOSE EGG FORMATION
Ts	SUNLIGHT GROUP-- Includes Trout Peak Trachyandesite, Wapiti Formation, Cresent Hill Basalt, and Mount Wallace Formation
Tt	THOROFARE CREEK GROUP--TEEPEE TRAIL FORMATION
Tta	TATMAN FORMATION
Tte	TEEWINOT FORMATION
Tw	WASATCH FORMATION
Twb	WAGON BED FORMATION
Twdr	WIND RIVER FORMATION
Twc	CATHEDRAL BLUFFS TONGUE OF WASATCH FORMATION
Twi	THOROFARE CREEK GROUP -- WIGGINS FORMATION
Twim	WIND RIVER AND INDIAN MEADOWS FORMATIONS
Twk	KINGSBURY CONGLOMERATE MEMBER OF WASATCH FORMATION
Twl	WILLWOOD FORMATION
Twm	WASATCH FOMATION -- MAIN BODY
Twmo	MONCRIEF MEMBER OF WASATCH FORMATION
Twp	SUNLIGHT GROUP--WAPITI FORMATION
Twr	WHITE RIVER FORMATION
Ugn	OLDEST GNEISS COMPLEX--Overprint pattern indicates area of migmatite related to emplacement of 2,600-Ma granite
Wg	GRANITIC ROCKS OF 2,600-Ma AGE GROUP
Wgd	GRANODIORITE OF THE LOUIS LAKE PLUTON
Wgn	GRANITE GNEISS
Wmu	METAMORPHOSED MAFIC AND ULTRAMAFIC ROCKS
Ws	METASEDIMENTARY ROCKS
WVsv	METASEDIMENTARY AND METAVOLCANIC ROCKS

Table 5. Explanation of codes for reclassified surficial geology units of northwest Wyoming and the Buffalo Resource Area from the digital surficial geology map of Wyoming (Case et al. 1998).

Surficial Geology Code	Explanation
Ai	Old alluvial plain with scattered deposits of eolian, residuum, and slopewash
ai	Alluvium with scattered deposits of terrace, slopewash, eolian, residuum, grus and glacial
aR	Shallow alluvium mixed with scattered bedrock outcrops
bi	Bench including eolian, slopewash, outwash, and bench and/or mesa
bdi	Dissected bench with scattered deposits of residuum, slopewash, landslide, and eolian
tdi	Dissected terrace deposits mixing with alluvium, residuum, eolian, and slopewash
ti	Terrace deposits mixed with scattered deposits of alluvium, residuum, eolian, slopewash, and outwash
tre	Shallow terrace deposits mixed with scattered deposits of eolian and residuum
fi	Alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash, residuum, and eolian
fdi	Dissected alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash and residuum
mi	Mesa including scattered deposits of residuum and eolian
ei	Eolian mixed with scattered deposits of residuum, alluvium, and slopewash
oai	Glacial outwash and alluvium mixed with scattered deposits of glacial, terrace, hot spring, bedrock outcrops, residuum, slopewash and grus
gi	Glacial deposits mixed with scattered deposits of slopewash, residuum, grus, alluvium, colluvium, landslide, and/or bedrock outcrops
li	Landslide mixed with scattered deposits of slopewash, residuum, Tertiary landslides, and bedrock outcrops; landslides too small and numerous to show separately
pea	Playa deposits mixed with scattered deposits of alluvium, eolian, and r; playa deposits too small to show separately
sci	Slopewash and colluvium mixed with scattered deposits of slopewash, residuum, grus, glacial, periglacial, alluvium, eolian, and/or bedrock outcrops
ri	Residuum mixed with alluvium, eolian, slopewash, grus, and/or bedrock outcrops
ui	Grus mixed with alluvium, eolian, slopewash, grus, and/or bedrock outcrops
Ri	Bedrock and glaciated bedrock including hot spring deposits and volcanic necks; mixed with scattered shallow deposits of eolian, grus, slopewash, colluvium, residuum, glacial, and alluvium.
Mi	Mined areas mixed with scattered deposits of residuum, slopewash, and/or bedrock outcrops
Ki	Karst areas mixed with scattered deposits of residuum, slopewash, alluvium and/or bedrock outcrops
ki	Clinker mixed with scattered deposits of residuum, slopewash, alluvium and/or bedrock outcrops
xi	Truncated bedrock mixed with scattered shallow deposits of eolian, terrace, residuum, alluvium, old alluvial plain, bench, and slopewash
Ti	Structural terrace including and/or mixed with deposits of alluvium, eolian, residuum, slopewash, and terrace

Table 6. Explanation of single element codes for the surficial geology coverage (Case et al. 1998). These codes are combined into a multi-element classification for a specific mapping unit with the single elements ranked from most dominant to least dominant.

Surficial Geology Code	Explanation
A	old alluvial plain - a broad, relatively flat deposit formed by the regional erosion of coalescing alluvial and associated alluvial deposits.
a	alluvium - stream and river deposits.
b	bench - a strip of relatively level earth or rock, raised and capped with gravel.
b/m	bench and/or mesa (could not be determined from aerial photos)
c	colluvium - loose and incoherent deposits, usually at the foot of a cliff or on the surface of a slope and there chiefly by gravity.
d	dissected
e	eolian deposits - wind blown deposits, includes sand, silt, and clay
f	alluvial fan deposits - a fan shaped deposit made by a stream or a debris flow where they have run out onto a level plain.
G	glaciated bedrock - bedrock that has been scoured and carved out by glacial action.
g	glacial deposits - deposits that have been formed through glacial action, such as till and moraine.
h	hot spring deposit - travertine and silaceous sinter deposits.
i	includes other surficial deposits (25 element classification)
K	Karst - a type of topology formed over limestone, dolomite, gypsum, or other salts by dissolving or solution, and that is characterized by closed depressions or sinkholes.
k	clinker - bedrock that has been baked and fused as a result of a burning coal seam.
L	Tertiary landslide
l	landslide - earth and rock which became loosened from a hillside and slides, flows, or falls down the slope.
M	large open pit mine/quarry
m	mesa - a bedrock capped plateau or tableland.
o	glacial outwash - alluvium and drift deposited by meltwater streams beyond active glacier ice.
p	playa lake - broad, shallow sheets of water which quickly gather and evaporite, leaving mud flats or broad, shallow deposits.
q	periglacial deposits - patterened ground associated with nearby glaciated areas.
R	bedrock
r	residuum - a residual deposit remaining in place after the decomposition of rocks.
s	slopewash - soil and rock material that has been moved down a slope by gravity assisted by running water.
T	structural terrace - a terrace cut in bedrock that is mantled with a thin veneer of alluvium.
T/t	structural terrace and/or terrace deposits (could not be determined from aerial photos)
t	terrace deposits - relict alluvial deposits on relatively flat, horizontal, or gently inclined surfaces which are bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.
u	grus - an accumulation of angular, coarse- grained fragments resulting from the granular disintegration of crystalline rocks.
v	volcanic neck - cylindrical to spire-shaped form that is a remnant of solidified magma that filled the vent of an extinct volcano.
w	lacustrine deposits - deposits associated with lakes.
x	truncated, upturned bedrock

Table 7. Description of Soil Mapping Units (SMU) of Wyoming from the digital surficial soils map of Wyoming (Munn and Arneson 1998).

Soil Mapping Unit	Explanation
Soil Zone 1	**Yellowstone National Park Area. Mountains and high plateau. Cryic, udic and aquic.**
WY01	Typic Dystrocryepts-Typic Haplocryalfs, loamy-skeletal, mixedand Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed. Under continuous coniferous forest (Lodgepole Pine, Englemann Spruce, Subalpine Fir, and Douglas Fir) soils on geologic parent materials and surfaces that are older than Pinedale are typically Haplocryalfs. The Yellowstone Plateau area was heavily glaciated during the Pinedale (Wisconsin) glaciation and most surfaces are of Late Pinedale or Holocene age. On these younger parent materials and/or surfaces, the dominant soils are Dystrocryepts. Cryaquepts occur in riparian areas. Inclusions may include Typic Cryofluvents along small channels and Cryofibrists in depressions in Pinedale moraines and along low gradient segments of streams. Typic Haplocryolls and Humic Dystrocryepts may occur in small openings in the forest.
WY02	Typic Haplocryolls, fine-loamy and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. Haplocryolls occur in mountain meadows which are predominately on south and west facing slopes, and are often on finer textured parent materials than surrounding forest soils. Cryaquepts occur along riparian areas.
WY03	Typic Cryorthents and Humic Dystrocryepts, loamy-skeletal and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. Topography for this unit is irregular, with Humic Dystrocryeptss occurring under grass or grass with scattered trees on small benches and low gradient segments of the slope. Cryorthents are on very steep slopes and around the base of rock outcrops. Cryaquepts occur along riparian areas.
Soil Zone 2	**Absaroka Volcanics. Mountains. Cryic, udic and aquic.**
WY03	Typic Cryorthents and Humic Dystrocryepts, loamy-skeletal and Histic Cryaquepts, fine-loamy over sandy or sandy skeletal. Soils are similar to those in Soil Zone 1, except that the mineralogy reflects volcanic parent materials.
WY04	Typic Cryorthents, loamy-skeletal; Rock Outcrop; and Histic Cryaquepts, fine-loamy over sandy or sandy- skeletal. Thin Cryorthents and bedrock outcrops dominate this landscape. In narrow riparian areas between steep slopes, Cryaquepts have developed in accumulations of fine materials weathered from the surrounding uplands.
WY05	Histic Cryaquepts fine-loamy over sandy or sandy-skeletal and Humic Dystrocryepts, loamy skeletal. In alpine settings, the soils over most of the landscape are an association of Cryaquepts in riparian areas and Humic Dystrocryepts, with moderately deep profiles, on uplands. Umbric epipedons contain 6 to 8% organic matter and are typically 25 to 50 cm thick.
Soil Zone 3	**Middle Rocky Mountains. Cryic, udic and aquic.**
WY06	Typic Haplocryalfs, Typic Dystrocryepts and Typic Haplocryolls, loamy-skeletal and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal. On stable slopes which are older than Pinedale (Late Wisconsin), the predominate soils are Haplocryalfs. Dystrocryepts occur on slopes greater than 40%, and on Pinedale and younger surfaces (Pinedale tills and holocene surfaces). Haplocryolls occur under mountain meadow vegetation and are most common on south facing slopes. Cryaquepts are found along narrow riparian areas.
WY07	Typic Haplocryolls, fine-loamy; Chromic Haplocryerts, fine and Histic Cryaquepts, fine-loamy. These soils occur on Mesozoic age bedrock with the Haplocryerts predominating on marine shales. Dominate vegetation is grass or forest with thin canopy coverage and clusters of aspen in wet areas. Cryaquepts predominate in riparian areas.
WY08	Rock outcrop and Lithic Cryorthents, loamy-skeletal. These residual landscapes present a rugged appearance with 50 to 60% of the area covered by rock outcrop. The thin Cryorthents occur intermingled with the bedrock.

Table 7 (continued)

Soil Mapping Unit	Explanation
WY42	Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frigid. These soils occur in the foothills along the flank of the higher mountains and represent a transition from the basins to the higher mountains. Hapludolls are common on south and west facing slopes; Hapludalfs predominate on north facing slopes and on both canyon walls of narrow canyons.
Soil Zone 4	**Bighorn Basin. Intermountain Basin. Mesic, aridic.**
WY09	Typic Haplargids and Typic Haplocalcids, fine-loamy over sandy or sandy-skeletal, mesic and Typic Torriorthents, fine-loamy and coarse-loamy, mesic. Aridisols occur on colluvial and alluvial landscapes while Entisols occur on residual landscapes.
WY10	Typic Torripsamments, mesic. These soils are on stabilized dunes. They show little horizon development; thin A horizons are the most apparent change from the parent material (stabilized dune sand).
WY11	Calcic Haplosalids, fine, mesic. These soils are associated with marine shales and occur in topographic depressions where run off water from the surrounding landscape accumulates and evaporates concentrating salt.
WY12	Typic Torriorthents, loamy, mesic and Rock Outcrop. These soils form in a variety of sedimentary parent materials which are exposed along the perimeter of the basin. Soils are shallow or moderately deep to soft bedrock.
WY13	Typic Torriorthents, fine, mesic and Rock Outcrop. These soils form over fine textured Cretaceous bedrock. Outcrops of shale occur as small badlands; outcrops of coarser textured rock support long, narrow ridges with finer textured soils along the flanks.
WY14	Typic Haplargids and Typic Natrargids, fine-loamy or coarse-loamy, mesic. These soils occur on low gradient colluvial slopes (less than 15%) and reflect the texture of the underlying bedrock as well as the effects of slope processes.
WY15	Typic Torrifluvents, sandy-skeletal, mesic and Typic Haplocambids, fine-loamy over sandy or sandy- skeletal, mesic. These soils occur on Holocene age terraces and slopes along small streams. The Torrifluvents occupy the first and second terraces above the modern channel.
Soil Zone 5	**Powder River Basin. Northern Great Plains. Mesic, aridic.**
WY16	Ustic Haplargids, Ustic Haplocalcids and Aridic Haplustolls, fine-loamy, mesic and Torriorthents, loamy- skeletal, mesic. These soils have formed from a variety of parent materials on Pleistocene and Holocene surfaces, weathered from Tertiary and other bedrocks. The Haplargids and Haplocalcids occur across broad expanses of the landscape. The Torriorthents occur along eroded drainage ways and around rock outcrops. The Haplustolls occur where snow accumulation significantly enhances soil water.
WY17	Typic Torriorthents, loamy-skeletal, mesic and Rock Outcrop. These stony soils occupy ridge crests where coal bed fires have created clinker. The soils tend to be much coarser than the soils on the adjacent lower slopes, and contain hard clasts.
WY18	Typic Torriorthents and Entic Haplustolls, fine-loamy, mesic. These soils occur on reconstructed landscapes which had been disturbed by mining. The occurrence of mollic epipedons is a function of reclamation practices and is not necessarily tied to topography or potential productivity.
WY19	Typic Haplogypsids, fine, mesic. These soils occur in clayey playas where gypsum has accumulated in sufficient quantity to qualify as a gypsic horizon.
WY42	Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frigid. These soils are similar to those in Soil Zone 3. They occur in foothills along the margin of the Powder River Basin.
Soil Zone 6	**Black Hills. Mountains. Frigid, udic and ustic.**
WY20	Typic Hapludalfs and Typic Argiudolls, fine-loamy and Typic Haplaquolls, fine, frigid. The

Table 7 (continued)

Soil Mapping Unit	Explanation
	Hapludalfs support open to dense stands of Ponderosa Pine. The Argiudolls occur under moist meadows, while the Haplaquolls occur along narrow riparian areas.
WY21	Ustic Haplocambids and Ustic Torriorthents, fine, frigid and Rock Outcrop. These clayey soils are derived from acid shales and show little profile development. The Haplocambids occur on low gradient surfaces. Torriorthents occur intermingled with areas of shale outcrop in badlands-type topography.
WY22	Typic Argiudolls and Typic Haplaquolls fine-loamy, frigid. These soils occur in moist meadows along riparian areas in the mountains. The Haplaquolls have accumulated greater amounts of organic matter due to their high water table.
WY43	Ustic Haplargids and Ustic Haplocambids fine and fine-loamy, mesic. These soils have weathered from interbedded sandstones, siltstones and shales. The Haplargids are on low gradient slopes (less than 15%); the Haplocambids are on steeper slopes.
Soil Zone 7	**Southeast Wyoming. Northern Great Plains. Frigid and mesic, aridic.**
WY10	Typic Torripsamments as in Zone 4, except soil temperature regime is frigid.
WY23	Typic Argiustolls, fine-loamy and Typic Argiustolls fine-loamy over sandy or sandy-skeletal, mixed, frigid. These soils occur on Tertiary and Pleistocene parent materials (mostly alluvial fan deposits of Tertiary age, or local alluvium of Pleistocene age.)
WY24	Ustic Haplocambids and Ustic Torriorthents, fine, frigid. These moderately and weakly developed soils occur on gentle to steep slopes over the Tertiary White River formation. Profile development is shallow or moderately deep.
WY25	Ustic Torriorthents and Aridic Ustochrepts, loamy-skeletal, frigid. These soils occur along the front of the Laramie Range and the Hartville uplift. The Ustochrepts support scattered stands of Ponderosa Pine. Soils are shallow or moderately deep and coarse textured.
WY26	Ustic Torriorthents and Ustic Haplocambids, fine, frigid. These soils have developed on Cretaceous age bedrock (shale) and are moderately deep or shallow. The Haplocambids are on low gradient fans and slopes; Torriorthents occur on steeper slopes (greater than 15%).
WY27	Typic Torrifluvents and Typic Haplaquolls, fine-loamy over sandy or sandy-skeletal, mixed, frigid These soils occur along riparian areas with the Torrifluvents developing along channels scoured by flooding and the Haplaquolls developing on low gradient channel sections where vegetation is well established and high water tables occur during most of the year.
WY44	Ustic Haplargids and Ustic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic. These soils occur on alluvium and slopes of Pleistocene and Holocene age over a variety of bedrocks. The Torrifluvents occur on the active floodplain; Haplargids occur on more stable landscape segments.
Soil Zone 8	**Medicine Bow and Laramie Mountains. Mountains. Cryic, udic and aquic.**
WY28	Typic Haplocryalfs and Typic Dystrocryepts, loamy-skeletal, mixed and Typic Haplocryolls, fine loamy, mixed. Haplocryalfs occur under forest on till parent materials older than Pinedale (140,000 years old and older) and on non-glaciated landforms where the slope gradient is less than approximately 10%. Dystrocryepts occur under forest on till of Pinedale age and on slopes (&gt;10%) that were unstable during the Pinedale glaciation. Haplocryolls occur under grasses and shrubs on west and south aspects and in dry parks on Tertiary age parent materials.
WY29	Histic Cryaquepts and Typic Cryaquolls, fine-loamy over sandy or sandy-skeletal, mixed. These are poorly drained soils along riparian areas. Only A horizon thickness is different between the two soils (thicker in the Mollisols). Depth to water table in the profile varies from 0 to 50 cm over the course of the summer.
WY30	Typic Dystrocryepts and Lithic Cryorthents, loamy skeletal, mixed and Rock Outcrop. These

Table 7 (continued)

Soil Mapping Unit	Explanation
	soils are found at high elevation and on very resistant parent materials. They are on eroding slopes, or the youngest tills in the region (Neoglacial).
WY31	Typic Dystrocryepts and Typic Cryorthents, loamy skeletal, mixed. This unit occurs on Triassic, Permian and Cretaceous sedimentary rock along the flanks of the mountain range. The soils are moderately deep or shallow.
WY32	Typic Dystrocryepts, loamy-skeletal, mixed and Rock Outcrop. These soils occur on Precambrian granitic parent materials. The Inceptisols are mostly moderately deep with less than 12% clay in their thin B horizons (Bw). The rock outcrops take the form of rounded boulders and sheets of rock.
WY45	Typic Hapludalfs and Aridic Haplustepts, loamy-skeletal, mixed, frigid. These soils occur along the base of the mountain ranges in the region and support open stands of Ponderosa pine as well as other conifers. The Hapludalfs are on low relief slopes and nearly level surfaces. The Haplustrepts are on slopes greater than 15% and on the narrow valley floors of canyons.
Soil Zone 9	**Laramie and Wind River Basins. Intermountain basins. Frigid, aridic.**
WY09	Ustic Haplargids and Ustic Haplocalcids, fine-loamy over sandy or sandy-skeletal, frigid and Ustic Torriorthents, fine-loamy and coarse-loamy, frigid. In this region, the soils in this unit have frigid temperature regimes. These soils occur on old alluvial terraces along major rivers. Soils younger than mid-Pleistocene age are an association of Haplargids and Haplocalcids. On older landscapes,Haplocalcids predominate. Torriorthents occur along south facing terrace scarps; textural family is determined by underlying bedrock.
WY10	Typic Torripsamments, frigid. These soils on stabilized dunes show little profile development, but are quite productive under native rangeland.
WY33	Lithic Torriorthents, loamy-skeletal, frigid and Rock Outcrop. These soils occur along both sides of bedrock outcrops that form ridges along the flanks of the basins. The rock outcrop is usually sandstone or limestone.
WY34	Ustic Haplargids and Ustic Natrargids, fine-loamy, frigid. These soils occur as an association on residual landscapes and in local colluvium derived from Tertiary age parent materials. Natrargids show less productivity under sagebrush and grass than Haplargids.
WY35	Typic Natrargids and Typic Torriorthents, fine, frigid. These soils occur on landscapes underlain by Triassic and Cretaceous bedrock (shales). The Torriorthents occur in a badlands type topography, while the Natrargids occur on small, local alluvial fans at the foot of badland scarps, and on low gradient slopes.
WY36	Ustic Torriorthents and Ustic Haplocalcids, coarse-loamy, frigid. These soils occur on calcareous sandstone of Permian age (redbeds). Haplocalcids occur on low gradient slopes; Torriorthents on slopes greater than 10%.
WY37	Typic Petrocalcids and Ustic Calciargids, fine-loamy over sandy or sandy-skeletal, frigid. These soils occur on the highest terraces along major streams where the surfaces are mid Pleistocene age or older. On some surfaces, the petrocalcic horizon of the Palecalcids is nearly continuous; on other surfaces, Palecalcids and Haplocalcids occur as a complex.
WY38	Ustic Haplocambids and Ustic Haplargids, coarse-loamy, frigid. These soils occur as a complex on late Pleistocene age terraces along major streams, and on slopes of less than 15% gradient of the same age.
WY44	Ustic Haplargids and Typic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic. These soils occur below 5000 feet in elevation in a relatively small area in the Wind River Basin. The Haplargids occur on alluvial terraces; the Torriorthents occur along the scarp slopes.
Soil Zone 10	**Green River Basin. Intermountain basin. Frigid, aridic.**

Table 7 (continued)

Soil Mapping Unit	Explanation
WY06	Typic Haplocryalfs, Typic Dystrocryepts and Typic Haplocryolls, loamy-skeletal, mixed and Histic Cryaquepts, fine-loamy over sandy or sandy-skeletal, mixed. These soils are similar to those in the same unit in Soil Zone 3. They are confined to the highest elevations of this region.
WY10	Typic Torripsamments, frigid. These soils are very similar to Torripsamments in other areas of the state, except that they are intermingled with active dunes.
WY11	Typic Haplosalids, fine, frigid. These Haplosalids occur in saline playas and are similar to those of this unit in Zone 4, except that they are frigid.
WY17	Rock Outcrop and Typic Torriorthents, loamy-skeletal, mixed, frigid. These soils are similar to those in Soil Zone 5 except that the coarse fraction of the soil consists of clasts of the local bedrock, rather than clinker.
WY39	Ustic Haplargids, Ustic Haplocambids and Ustic Natrargids, fine-loamy, mixed, frigid. On Tertiary parent materials along the flank of the Wyoming Range uplift, the soils are found in an association reflecting slope position and parent material sodium content. The Haplargids occur on stable, low gradient slopes. Haplocambids are on steeper slopes and Natrargids occur on fans where erosional processes have accumulated high sodium materials.
WY40	Ustic Haplocambids and Ustic Torriorthents, coarse-loamy, mixed and Typic Torrifluvents, loamy skeletal, mixed, frigid. This landscape has shallow and moderately deep Haplocambids and Torriorthents occurring on slopes along ephemeral channels and Torrifluvents along gully bottoms.
WY41	Aridic Haplustolls and Ustic Haplocambids, fine-loamy, frigid. These soils are on Tertiary age parent materials along the edges of the basins under sagebrush-grasslands. The Haplustolls are on sites with extra moisture which promotes greater productivity.

Table 8. Description of Landtype Associations types for the Bridger-Teton National Forest. More detailed descriptions are available in Svalberg et al. (1997). Note not all Landtype Associations are described.

Dodge Butte Landtype Association

This LTA is located along the foothills of the Gros Ventre Range, north of the Green River. The LTA is dominated by south-facing bedrock controlled slopes and lateral moraines extending from the Green River trough. The LTA is dominated by big sagebrush shrublands, coniferous forests, and aspen forests.

Elk Ridge Landtype Association

This LTA is located on the southeastern part of the Gros Ventre Range in broadly folded uplands directly west of the Green River Valley. The LTA is dominated by coniferous forests and grasslands.

Green River Valley Landtype Association

This LTA represents the broad, deep, glacial trough of the Upper Green River Valley. The LTA is dominated by big sagebrush, shrublands, aspen forests, and riparian shrublands.

Gypsum Mountain Landtype Association

This LTA is characterized by smooth-crested sedimentary mountain peaks and summits. Rock outcrop, rubble land, and alpine tundra dominate this LTA. Some areas have sparse conifer cover.

Little Sheep Mountain Landtype Association

This LTA is located on folded Paleozoic and Mesozoic sedimentary strata. Much of the LTA was overridden by Pleistocene glacial advances. Higher elevations near Big Sheep Mountain remained unglaciated. The LTA is dominated by coniferous forests and big sagebrush shrublands.

Mill Creek Landtype Association

This LTA is located in the northern part of the Wind River Range where Paleozoic rocks are exposed on steep trough walls. This LTA is dominated by coniferous forests and big sagebrush shrublands.

Pass Peak Landtype Association

This LTA is characterized by the presence of well-rounded quartzitic gravels and cobbles derived from Pass Peak formation (Eocene). The area is on the drownthrown block (southern part) of the East Elbow Mountain Fault. This LTA is dominantly coniferous forests and forblands.

Pinyon Ridge Till Plain Landtype Association

This LTA is characterized by broad glaciated till plains from Pleistocene glacial advances. The landscape is dominated by sagebrush shrublands and conifer forests. Large glacial erratics and kettles are scattered throughout the LTA.

Tosi Creek Basin Landtype Association

Tosi Creek Basin is a moderately-gentle dipping slope (5 to 10°) of dominantly karst-like topography which was uplifted by the Cache Creek Thrust Fault. The LTA is dominated by rock outcrop and grassland.

Table 8 (Continued)

Western Peaks Landtype Association

This LTA is located on the western flank of the high peaks of the Wind River Range. The LTA is dominantly rock and alpine tundra.

Boulder Basin Landtype Association

This LTA is found along the escarpment extending from the Tertiary erosion surface to the glaciated foothills in the northwestern part of the Wind River Range. Parent material is dominantly glacial till and colluvium derived from Precambrian granite gneiss. Bedrock is dominantly Precambrian granite gneiss with abundant small areas of Tertiary, Mesozoic, and Paleozoic sedimentary rocks present in the footwall of the Wind River Thrust Fault at lower elevations. Vegetation is dominantly coniferous forests with a small percentage of riparian community types.

Drumlin Meadows Landtype Association

This LTA consists of the drumlins, ground moraines, till-mantled mountain slopes, and bedrock knobs on glacial mountain slopes with grassland vegetation. Rock knobs are typically dominated by coniferous forests.

Fir Zone Subsummit Landtype Association

This LTA occurs on the western half of the high-elevation subsummit erosion surface. The LTA is dominated by coniferous forests and rock outcrop, with small areas of grasslands, riparian shrublands, aspen forests, and mountain big sagebrush shrublands.

Glacial Troughs Landtype Association

This LTA is located where Pleistocene glaciers have excavated very large U-shaped glacial troughs throughout the northwestern part of the Wind River Range. These troughs are typically very steep-sided and dominated by bedrock outcrops and rubble land. Vegetation ranges from alpine tundra near trough headwalls to big sagebrush near trough mouths. Rock falls, avalanche chutes, and scree slopes are common.

Spruce Zone Subsummit Landtype Association

This LTA occurs on the high-elevation erosion surface of the western flank of the Wind River Range. Vegetation types are primarily coniferous forests (Engleman spruce and whitebark pine). The LTA consists of glacial and glacially scoured landforms.

Mountain Front Landtype Association

This LTA is located along the escarpment which separates the high-level (Tertiary) erosion surface from the lower elevation Green River Basin on the southwestern part of the Wind River Range. The escarpment is generally located from 5 to 8 miles west of the crest of the range. This LTA is dominated by coniferous forests, aspen forests, and bog sagebrush shrublands. This LTA alternates with the Glacial Troughs LTA in defining the western perimeter of the Subsummit Uplands Subsection.

Tundra Zone Subsummit Landtype Association

This LTA occurs in the alpine settings at higher elevation than the coniferous zones of the subsummit erosion surface. The LTA includes a large percentage of rock outcrops and talus.

Table 8 (Continued)

Colluvial Southeast Mountains Landtype Association

This LTA consists of dominantly nonglaciated, bedrock-controlled mountain slopes of the southwestern part of the Wind Rover Range. Vegetation is dominantly coniferous forests and big sagebrush shrublands.

Glaciated Southeastern Mountain Landtype Association

This LTA occurs where large Pleistocene glaciers deposited moraines in the southwestern part of the Wind River Range. The vegetation is mostly coniferous forests, with smaller percentages of riparian grasslands and aspen forests.

Tertiary Southeastern Mountains Landtype Association

This LTA occurs on the Tertiary sedimentary rocks of the South Pass Formation (Pliocene and Upper Miocene) at lower elevations of the southern Wind River Range. The dominant vegetation types are sagebrush shrublands, aspen, and coniferous (Douglas fir) forests.

Glaciated Foothills Landtype Association

This LTA is located along the foothills of the Gros Ventre and Wind River Ranges. The LTA is composed primarily of glacial and glaciofluvial deposits from adjacent mountains. These deposits are often much coarser-grained than the Tertiary lacustrine and alluvial deposits which fill the majority of the Green River Basin. Vegetation is predominantly big sagebrush shrublands, aspen forests, and coniferous forests.

McDowell Flat Landtype Association

This LTA is located along the northeastern edge of the Green River Basin and the base of the northwestern flank of the Wind River Range. The LTA is characterized by numerous potholes and kettles found in Pleistocene lateral moraines extending from Green River trough. The dominant vegetation types are big sagebrush shrublands, aspen forests, and coniferous forests. Small kettles and potholes provide riparian features in this LTA.

Table 9. Description of Landtype Associations for the Bighorn National Forest.

A01 M331Ba-01 SEDIMENTARY BREAKLANDS

Map Units Included: 1/3 14, 15, 1/2 22, 32, 34, 35, 62, 71, 75, 77, 90, 91

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Sedimentary Subsection.

Concept: This LTA is typically composed of steep mountainsides, escarpments and canyon walls, and steep colluvial slopes. The vegetation is a mosaic of Douglas fir forest, shrubland, and mountain grasslands.

General Characteristics:
Topography: Steep mountainsides, escarpments, talus; relief 1500 - 2500'.
Elevation: 5000 - 9000'
Slope: 40 to 70%
Extent: 188,525 acres for IRI; 134,068 acres within Forest; 12.0% of Forest.
22,301 acres of grass, 2.0%; 111,767 acres of trees, 10.0%
Climatic Zone: Lower Montane, Lower Montane and Montane, and Montane
Average Annual Precipitation: 15 to 35 inches
Formations: Bighorn Dolomite, Madison Limestone, Amsden Formation, Tensleep Sandstone.
Lithology: Sandstone, Limestone, Dolomite, Interbedded sandstone and shale
Parent Material: Sedimentary residuum and colluvium
Potential Natural Vegetation: Douglas fir, mountain ninebark, Utah juniper, mountainmahogany, big sagebrush, Idaho fescue, bluebunch wheatgrass
Soil Classification: Typic Cryoboralfs - 60%
Ustic Torriorthents - 25%
Rock Outcrop - 15%

A02 M331Ba-02 LANDSLIDE/COLLUVIAL DEPOSITS

Map Units Included: 17, 20, 30

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Sedimentary Subsection.

Concept: This LTA is typically composed of moderately stable to stable landslide deposits. The vegetation is mostly mountain shrubland and grassland.

General Characteristics:
Topography: Complex slopes, relief from 200 to 600'
Elevation: 5000 - 9000'
Slope: 10 to 40%

Extent: 38,838 acres for IRI; 35,295 arcres within Forest; 3.2% of Forest; all grass/shrub.
Climatic Zone: Lower Montane and Montane, Montane, Montane and Subalpine
Average Annual Precipitation: 15 to 30 inches
Formations: Flathead Sandstone, Gros Ventre Formation, Gallatin Limestone, Bighorn Dolomite, Madison Limestone, Amsden Formation, Tensleep Sandstone, Chugwater Formation
Lithology: Colluvial/landslide deposits.
Parent Material: Colluvium from limestone, shale, and sandstone.

Table 9 (continued)

Potential Natural Vegetation: Big sagebrush, Idaho fescue, black sagebrush, bluebunch wheatgrass.
Soil Classification: Typic Cryorthents - 60%
Argic Cryoborolls - 40%

A03 M331Ba-03 SEDIMENTARY MOUNTAIN SLOPES (LIMESTONE/DOLOMITES)

Map Units Included: 2/3 14, 21, 1/2 22, 24, 27, 39, 63, 66, 67, 68, 69, 70, 74, 78, 79, 80, 81, 82, 83, 92, 93, 96

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Sedimentary Subsection.

Concept: This LTA is typically composed of mountainsides, ridges, toeslopes, and fans. The vegetation is a mosaic of mountain grassland and Douglas fir/Engelmann spruce forest.

General Characteristics:
Topography: Moderate complex slopes, strongly dissected.
Elevation: 5500 to 10,500'
Slope: 5 to 30%
Extent: 215,481 acres for IRI; 166,282 within Forest; 14.9% of Forest.
103,357 acres of grass, 9.0%; 62,925 acres of trees, 5.9%
Climatic Zone: Montane, Montane and Subalpine
Average Annual Precipitation: 15 to 35 inches
Formations: Gallatin Limestone, Bighorn Dolomite, Madison Limestone.
Lithology: Limestone and dolomite
Parent Material: Residuum, colluvium, and alluvium (calcareous)
Potential Natural Vegetation: Douglas fir, Engelmann spruce, mountain ninebark, grouse whortleberry, Idaho fescue, silky lupine.
Soil Classification: Typic Cryoboralfs - 50%
Argic Cryoborolls - 40%
Calcic Cryoborolls - 10%

A04 M331Ba-04 SEDIMENTARY MOUNTAIN SLOPES, SHALE/SANDSTONE (CALCAREOUS)

Map Units Included: 12, 28, 1/2 29, 42, 64, 65, 72, 97, 98, 99

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Sedimentary Subsection.

Concept: This LTA is typically composed of mountainsides, toeslopes, and fans. The vegetation is a mosaic of mountain shrubland and grassland.

General Characteristics:
Topography: Moderately dissected mountain slopes
Elevation: 6000 to 9500'
Slope: 2 to 35%
Extent: 57,136 acres for IRI; 27,058 within Forest; 2.5% of Forest; all grass/shrub
Climatic Zone: Lower Montane, Lower Montane and Montane, Montane, Montane and Subalpine.

Table 9 (continued)

Average Annual Precipitation: 15 to 35 inches
Formations: Gallatin Limestone, Amsden Formation, Tensleep Sandstone, Chugwater Formation.
Lithology: Interbedded sandstone, limestone, and shale.
Parent Material: Residuum, colluvium, and alluvium
Potential Natural Vegetation: Idaho fescue, big sagebrush, bluebunch wheatgrass, silky lupine.
Soil Classification: Argic Cryoborolls - 70%
Lithic Argiborolls - 30%

A05 M331Ba-05 SEDIMENTARY MOUNTAIN SLOPES, SHALE/SANDSTONE, (NONCALCAREOUS)

Map Units Included: 23, 1/2 29, 38, 43

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Sedimentary Subsection.

Concept: This LTA is typically composed of mountainsides, toeslopes, and fans. The vegetation is a mosaic of lodgepole pine/Engelmann spruce forest and grasslands.

General Characteristics:
Topography: Moderately dissected mountainsides.
Elevation: 6000 to 10,000'
Slope: 2 to 35%
Extent: 85,855 acres for IRI; 81,617 acres within Forest; 7.3% of Forest
26,762 acres of grass, 2.4%; 54,855 acres of trees, 4.9%
Climatic Zone: Montane, Montane and Subalpine
Average Annual Precipitation: 15 to 35 inches
Formations: Flathead Sandstone, Gros Ventre Formation
Lithology: Interbedded sandstone and shale, sandstone, shale
Parent Material: Residuum, colluvium, and alluvium
Potential Natural Vegetation: Lodgepole pine, Engelmann spruce, grouse whortleberry, Idaho fescue.
Soil Classification: Typic Cryoboralfs - 55%
Argic Cryoborolls - 45%

B01 M331Bb-01 GRANITIC BREAKLANDS

Map Units Included: 31, 1/3 37

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Granitic/Gneiss Subsection.

Concept: This LTA is typically composed of steep mountainsides, escarpments, and canyon walls. Rock outcrop and rubble land are common. The sparse vegetation is mainly grassland, lodgepole pine, grouse whortleberry.

General Characteristics:
Topography: Complex slopes, strong dissection, relief 1500 - 2500'.
Elevation: 6500 - 10,500'
Slope: Dominately 40 to 70%
Extent: 44,406 acresfor IRI; 39,278 within Forest; 3.5% of Forest

Table 9 (continued)

14,495 acres of Rock outcrop/grass, 1.3%; 24,783 acres of trees/Rock outcrop; 2.2%
Climatic Zone: Montane and Subalpine, Subalpine, and Alpine
Average Annual Precipitation: 20 to 30 inches
Formations: Precambrian granite and gneiss
Lithology: Granite and/or gneiss
Parent Material: Residuum and colluvium
Potential Natural Vegetation: Alpine vegetation, lodgepole pine, grouse whortleberry
Soil Classification: Rock outcrop - 60%
Typic Cryoboralfs - 40%

B02 M331Bb-02 GLACIAL CIRQUELANDS

Map Units Included: 13, 2/337

Location: Bighorn Mountain range in northern Wyoming in Bighorn ,Mountain Section, Granitic/Gneiss Subsection.
Concept: This LTA is typically composed of glacial cirque headwalls, cirque basins, and periglacial rubble and talus. The vegetation is a sparse alpine community.

General Characteristics:
Topography: Very steep mountainsides, cirques.
Elevation: 9500 - 13,000'
Slope: 30 to 100%
Extent: 64,418 acres all within Forest; 5.8% of Forest; Rock outcrop
Climatic Zone: Alpine
Average Annual Precipitation: 30 to 40 inches
Formations: Precambrian granite and gneiss
Lithology: Granite and/or gneiss
Parent Material: Residuum and talus
Potential Natural Vegetation: Sparse alpine plant community
Soil Classification: Rock outcrop, hard

B03 M331Bb-03 GLACIAL/TERTIARY TERRACE DEPOSITS

Map Units Included: 18, 19A, 19B, 41A, 41B

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Granitic/Gneiss Subsection.

Concept: This LTA is typically composed of glacial moraines and Tertiary terraces. The vegetation is a mosaic of lodgepole pine forest, shrubland, and mountain grasslands.

General Characteristics:
Topography: Bull Lake Stade: highly weathered moraine, Pinedale Stade: potholes and lakes moraine, old terraces.
Elevation: 6500 - 9000'
Slope: 2 to 40%
Extent: 105,715 acres for IRI; 99,140 acres within Forest; 9.0% of Forest

Table 9 (continued)

24,532 acres of grass, 2.2%; 74,608 acres of trees, 6.8%
Climatic Zone: Montane, Montane and Subalpine
Average Annual Precipitation: 15 to 35 inches
Formations: Precambrian granite and gneiss
Lithology: Granite and/or gneiss
Parent Material: Till and outwash
Potential Natural Vegetation: Lodgepole pine, grouse whortleberry, Idaho fescue, big sagebrush.
Soil Classification: Typic Cryoboralfs - 70%
Argic Cryoborolls - 30%

B04 M331Bb-04 GRANITIC MOUNTAIN SLOPES, STEEP

Map Units Included: 1/3 10

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Granitic/Gneiss Subsection.

Concept: This LTA is typically composed of steep mountainsides. The vegetation is dominately lodgepole pine forest.

General Characteristics:
Topography: Moderately dissected mountainsides.
Elevation: 7000 - 9500'
Slope: 25 to 50%
Extent: 42,826 acres for IRI; 41,767 acres within Forest ; 3.8% of Forest; all trees/Rock outcrop
Climatic Zone: Montane and Subalpine
Average Annual Precipitation: 15 to 35 inches
Formations: Precambrian granite and gneiss
Lithology: Granite and/or gneiss
Parent Material: Residuum
Potential Natural Vegetation: Lodgepole pine, grouse whortleberry
Soil Classification: Typic Cryoboralfs - 100%

B05 M331Bb-05 GRANITIC MOUNTAIN SLOPES, GENTLE

Map Units Included: 2/3 10, 11, 16, 25, 40

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Granitic/Gneiss Subsection.

Concept: This LTA is typically composed of mountainsides, fans, and outwash plain. Floodplains and wetlands are common. The vegetation is a mosaic of lodgepole pine/Engelmann spruce forest and mountain grasslands.

General Characteristics:
Topography: Moderately dissected mountain slopes, floodplains, wetlands.
Elevation: 7000 - 9500'

Table 9 (continued)

Slope: 5 to 25%
Extent: 318,046 acres for IRI; 303,242 acres within Forest; 27.2% of Forest
45,718 acres of grass, 4.1%; 257,524 acres of trees, 23.1%
Climatic Zone: Montane and Subalpine
Average Annual Precipitation: 15 to 35 inches
Formations: Precambrian granite and gneiss
Lithology: Granite and/or gneiss
Parent Material: Residuum and colluvium
Potential Natural Vegetation: Lodgepole pine, Engelmann spruce, grouse whortleberry, Idaho fescue.
Soil Classification: Typic Cryoboralfs - 75%
Argic Cryoborolls - 25%

B06 M331Bb-06 ALPINE MOUNTAIN SLOPES AND RIDGES

Map Units Included: 26, 33, 36

Location: Bighorn Mountain range in northern Wyoming in Bighorn Mountain Section, Granitic/Gneiss Subsection.

Concept: This LTA is typically composed of mountainsides, alpine ridges, and glacial trough valleys. The vegetation is dominately an alpine community and some Engelmann spruce forest.

General Characteristics:
Topography: Strongly dissected mountainsides, ridges, valleys.
Elevation: 9000 - 11,000'
Slope: 5 to 35%
Extent: 120,314 acres for IRI; 119,976 acres within Forest; 10.8% of Forest
108,162 acres of grass/Rock outcrop, 9.7%; 11,814 acres of trees, 1.1%
Climatic Zone: Subalpine, Alpine
Average Annual Precipitation: 25 to 35 inches
Formations: Precambrian Granite and Gneiss
Lithology: Granite and/or gneiss
Parent Material: Residuum and till
Potential Natural Vegetation: Sparse alpine community, Engelmann spruce
Soil Classification: Pergelic Cryumbrepts - 50%
Rock outcrop - 40%
Typic Cryoboralfs - 10%

Table 10. Explanation of codes for Landtype Associations of the Shoshone National Forest. It should be noted that the digital coverage and documentation for this Landtype Association map is still in draft form. We do not have mapping unit names for all of the Landtype Associations shown in Figure 34.

Beartooth Subsection

A01	Granitic valley bottoms - river floodplains
A02	Montaine granitic till deposits
A03	Glacial scoured granitic uplands
A04	Highly scoured granitic glacial uplands
A05	Glacial/fluvial granitic mountain slopes (steep)
A06	Till and scoured granitic uplands
A07	Glacial granitic mountain slopes
A08	Large lakebed deposits
A09	Beartooth Plateau
A10	Beartooth cirqueland
A12	Beartooth Butte sedimentary, residual and landslide deposits
A13	Table Mountain residual sedimentary and landslide deposits
A14	Granitic gorge, Clarks Fork box canyon
A15	Residual sedimentary mountain slopes and landslide deposits
A16	?
A17	?

Bighorn Basin Subsection

B01	River floodplains and adjacent terraces
B02	Mixed sedimentary fluvial foothills
B03	Mixed alluvial fans and fan piedmonts
B04	Foothills, moraines, and landslide deposits

Beartooth Foothills Subsection

C01	Mixed sedimentary till and landslide deposits
C02	Residual sedimentary, till, and landslides influenced mountain slopes
C03	Sedimentary influenced river floodplain and alluvium
C06	Mixed sedimentary mountain slopes and landslide deposits
C07	Mixed sedimentary till and landslide deposits
C10	Mixed sedimentary escarpments, mountain slopes, and landslide deposits
C14	Mixed sedimentary foothills and alluvial fans
C15	Fluvial volcanic mountain slopes

Northern Absaroka Range Subsection

D01	Glaciated volcanic cirquelands and associated alpine
D02	Volcanic glacial troughs
D03	Fluvial volcanic mountain slopes
D05	Volcanic valley bottoms
D06	Glacial - fluvial volcanic mountain slopes
D07	Mixed glacial valley bottoms and lucustrine deposits
D08	Fluvial volcanic mountain slopes
D09	Residual limestone mountain slopes

Table 10 (continued)

D14 Glacial fluvial volcanic mountain slopes
- D15 Volcanic valley bottoms

South Central Absaroka Range Subsection
- E01 Glaciated volcanic cirquelands and associated alpine
- E02 Volcanic glacial troughs
- E03 Fluvial volcanic mountain slopes
- E06 Glacial - fluvial volcanic mountain slopes
- E10 (E14) Fluvial volcanic mountain slopes
- E15 Volcanic valley bottoms

Absaroka Range Subsection
- F01 Glaciated volcanic cirquelands and associated alpine
- F02 Volcanic glacial troughs
- F03 Fluvial volcanic mountains slopes (Wiggins Formation)
- F05 Volcanic valley bottoms
- F06 Glacial - fluvial volcanic mountain slopes
- F10 Fluvial volcanic mountain slopes (Wiggins Formation)
- F13 Glacial fluvial volcanic steep mountain slopes
- F14 ?
- F15 Volcanic valley bottoms
- F17 Fluvial volcanic sedimentary mountain slopes and landslide deposits (Aycross Formation)
- F18 Fluvial mixed sediments mountain slopes (Teepee Trail Formation)
- F19 Fluvial mixed sedimentary mountain slopes (Teepee Trail Formation)
- F20 Fluvial volcanic sedimentary mountain slopes and landslide deposits

Wind River Absaroka Range Subsection
- G01 Glaciated volcanic cirquelands and associated alpine
- G02 Volcanic glacial troughs
- G05 Volcanic valley bottoms
- G06 Glacial fluvial mountain slopes
- G15 Volcanic valley bottoms
- G16 Residual - fluvial sedimentary mountain slopes
- G18 Fluvial mixed sediments "Teepee Trail Formation"
- G19 Fluvial mountain slopes "Teepee trail Formation"
- G20 Fluvial mountain slopes
- G22 Residual granitic mountain slopes (primarily Pe Formation)
- G23 Fluvial sedimentary mountain slopes
- G24 Mixed landslide deposits
- G25 Mixed glacial/landslide deposits
- G26 Mixed glacial till
- G27 Mixed landslide deposits from the Twi Formation
- G28 ?
- G99 Fluvial mountain slopes developed from the Tt Formation

Wind River Subsection
- H02 Granitic glacial till deposits
- H03 Till and scoured granitic uplands
- H04 Highly scoured granitic glacial uplands
- H07 Granitic mountain slopes

Table 10 (continued)

H09	Wind River granitic cryoplanated plateau
H10	Wind River granitic cirqueland
H18	Cryoplanated sedimentary upland
H24	Mixed sedimentary dipslopes and escarpments
H25	Residual granitic mountain slopes
H26	Residual granitic mountain slopes
H28	Granitic till and residual granitic surfaces
H29	Mixed sedimentary mountain slopes (noncalcareous)
H31	?
H32	Mixed till and moraine deposits
H33	Till and moraine deposits

Upper Wind River Range Subsection

I01	Glaciated volcanic cirquelands and associated alpine
I02	Volcanic glacial troughs
I05	?
I10	Glacial mountain slopes
I11	Glacial/fluvial volcanic mountain slopes
I15	Volcanic valley bottoms
I16	Residual - fluvial sedimentary mountain slopes
I17	Volcanic sedimentary glacial/fluvial and resultant landslide deposits
I18	Fluvial mixed sediments “Teepee Trail Formation”
I21	Mixed glacial fluvial basalt mountain slopes
I22	Mixed sedimentary (glacial, fluvial, and residual)
I23	Fluvial sedimentary mountain slopes
I24	Mixed landslide deposits
I25	Mixed glacial landslide deposits
I28	?

Table 11. Index of Aerial Photo Slides

ID#: 9800
Camera: Minolta SRT201
Lense: 50 mm
Filter: Skylight 1A

Date: 6 Jul 98
Film: Fujichrome Sensia II 100
Shutter Speed: 1/250s
(Exposures 12-25)

1	View south, Wyoming highway 37, near Bighorn Canyon National Recreation Area.
2	View south into Bighorn Basin from W side Bighorn Mtns, US highway Alt 14
3	View west into Bighorn Basin from W side Bighorn Mtns, US highway Alt 14
4	West side Bighorn Mtns, view to NW, US highway Alt 14
5	View S. into Bighorn Basin from W side Bighorn Mtns, US highway Alt 14
6	Bighorn River Valley near S end Bighorn Lake, US highway Alt 14, view to SW
7	N side Bridger Mtns near Thermopolis, view to SE Wyoming highway 120
8	S end Bighorn Basin near Thermopolis, view to ESE, Wyo highway 120
9	Beaver Divide, view to SE, Wyo highway 135
10	Beaver Divide, view to S, Wyo highway 135
11	Beaver Divide, view to E, Wyo highway 135
12	Wind turbines on Foote Creek Rim, view to S
13	
14	Medicine Bow River, NW of Foote Creek Rim, view to N
15	Elk Mountain, Medicine Bow River, view to SW
16	Hanna, view to the NW
17	Coal mines near Hanna, view to NE
18	Some cuestas NW of Hanna
19	Medicine Bow River, Seminoe Reservoir, view to N
20	Coal mines near Seminoe Reservoir
21	Coal mines near Seminoe Reservoir
22	Cuesta W of Seminoe Reservoir
23	Sand dunes on S side of Ferris Mtns
24	Sand dunes on S side of Ferris Mtns
25	Sand dunes on S side of Ferris Mtns

Index of Aerial Photos Slides (continued)

ID#: 9801
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 Muddy Gap, view to E
2 Whiskey Peak, view to W
3 Split Rock, Sweetwater River, view to N
4 Green Mtn, Crooks Mtn, view to SW
5 Green Mtn, Crooks Mtn, view to SW
6 Jeffrey City, Sweetwater River, Granite Hills, view to W
7 Soda Lakes
8 Granite Hills, Jeffrey City, Crooks Mtn, view to SW
9 Granite Hills, Crooks Gap, view to S
10 Beaver Divide, N of Jeffrey City, view to NW
11 Beaver Divide, view to WNW
12 Beaver Divide, view to W
13 Beaver Divide, view to WSW
14 Beaver Divide, Crooks Mtn, view to S
15 Cuestas, Beaver Divide, view to S
16 Cuestas, Beaver Divide, Crooks Mtn, view to SSE
17 Cuestas, near Beaver Divide
18 Beaver Divide, view to SW from near Oil Mtn
19 View NW from Beaver Divide
20 Oil Mtn (badlands)
21 Sand Draw, view to NW
22 Beaver Divide, view to S
23 Irrigated ag on Beaver Creek, view to N
24 Beaver Divide, US 287, view to SE
25 Beaver Creek near crossing of US 287, view to S
26 Cuesta W of Beaver Creek, view to WNW
27 Blue Ridge, view to NW
28 Red Bluff Canyon, view to ESE
29 Blue Ridge, view to NNW
30 Twin Creek S of US 287, view to N
31 S Wind River Mtns, high peaks, view to W
32 S Wind River Mtns, view to SW
33 E side Wind River Mtns, Table Mtn, view to NW
34 Red Canyon, view to S
35 Red Canyon, view to SSE
36 Wind River Peak, view to W
37 Sinks Canyon, view to SW

Index of Aerial Photos Slides (continued)

ID#: 9802 **Date:** 6 Jul 98
Camera: Minolta SRT201 **Film:** Fujichrome Sensia II 100
Lense: 50 mm **Shutter Speed:** 1/250s
Filter: Skylight 1A

1 Red Butte, W of Lander, view to W
2 North Fork Canyon, view to SW
3 North Fork Canyon, view to SW
4 E side Wind River Mtns, SSW of Fort Washakie, view to NW
5 E side Wind River Mtns, SW of Fort Washakie, view to SW
6 Washakie Reservoir, S. Fork Little Wind River, view to W
7 Washakie Reservoir, S. Fork Little Wind River, view to SW
8 Washakie Reservoir, S. Fork Little Wind River, view to SE
9 E side Wind River Mtns, Washakie Reservoir, view to ESE
10 E side Wind River Mtns, S of Bull Lake, view to WNW
11 Bull Lake, view to W
12 Bull Lake, view to W
13 Bull Lake, view to SW
14 Glacial deposits, Bull Lake, view to SW
15 Crowheart Butte, view to N
16 Irrigated ag at Crowheart, view to SW
17 Irrigated ag along Wind River near Crowheart view to NNW
18 Wind River Mtns W of Crowheart, view to SW
19 Dinwoody Lakes, view to W
20 Dinwoody Creek, view to N
21 Glacial deposits, Dinwoody Creek, view to NE
22 Badlands NW of Wilderness, view to NNW
•23 Red Rocks along US 287, near Red Creek, view to SW
24 Red Rocks along US 287, near Red Creek, view to S
25 E. Fork Wind River, view to N
26 Torrey Lake, view to SW
27 Torrey Creek, glacial deposits, view to SSE
28 Dubois Horse Creek, Ramshorn Peak, view to NNW
29 W end of Dubois, Ramshorn Peak, view to NNW
30 Valley W of Dubois, view to NW
31 Valley W of Dubois, view to WNW
32 Pinnacle Buttes Coffin Butte, Tappan Creek, view to NW
33 The Ramshorn, Little Horse Creek, view to NNW
•34 Horse Creek, Five Pockets, view to NNW
35 Spring Mtn, W of Wiggins Fork, view to N
36 Wiggins Fork, Lincoln Point, view to NNW
37 Black Mtn, Wiggins Fork, view to NW
38 E. Fork Wind River, Wind River Mtns, view to SW

Index of Aerial Photos Slides (continued)

ID#: 9803
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 Sand Draw SW of Black Mtn, view to S
2 Sand Draw SW of Black Mtn, view to SW
3 Cuestas SSE of Black Mtn, view to ENE
4 Cuestas E of Black Mtn, view to NNW
5 Cuestas E of Black Mtn, view to NW
6 Recessional escarpment, E side Dry Creek, view to SE
7 Dome NW of Maverick Spring Dome, view to NE
8 Dome NW of Maverick Spring Dome, view to NW
9 Dome NW of Maverick Spring Dome, view to NW
10 E side Maverick Spring Dome, view to NNW
11 E side Maverick Spring Dome, view to NW
12 Antelope Ridge, view to NW
13 E side Hurley Draw, view to SSE
14 S side Owl Creek Mtns, Muddy Creek, view to NNW
15 S side Owl Creek Mtns, cuestas E of Muddy Creek, view to NW
16 S side Owl Creek Mtns, cuestas W of W Fork Creek, view to NW
17 Owl Creek Mtns, view to N
18 Badlands W of Boysen Reservoir, view to S
19 Badlands W of Boysen Reservoir, view to S
20 Wind River Canyon, view to NE
21 Wind River Canyon, view to NNE
22 Boysen Dam, view to NNE
23 Wind River Canyon, view to N
24 Wind River Canyon, view to N
25 S side Bridger Mtns, view to ESE
26 S side Bridger Mtns, Birdseye Creek, view to N
27 S side Bridger Mtns, Steffen Hill, view to NE
28 S side Bridger Mtns, Dry Creek, view to NNW
29 S side Bridger Mtns, E side Steffen Hill, view to W
30 S side Bridger Mtns, view to WSW
31 S side Bridger Mtns, NE of Steffin Hill, view to WSW
32 S side Bridger Mtns, NE of Steffin Hill, view to WSW
33 E end of Bridger Mtns, view to SW
34 E end of Bridger Mtns. view to W
35 N side Bridger Mtns, view to WNW
36 N side Bridger Mtns, view to W
37 N side Bridger Mtns, view to W
38 N side Bridger Mtns, view to W

Index of Aerial Photos Slides (continued)

ID#: 9804
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 Red Bluffs on N side of Buffalo Creek, view to NE
2 Red Bluffs on N side of Buffalo Creek, view to NW
3 Red Bluffs on N side of Buffalo Creek, view to NW
4 Slopes E of Wind River Canyon, view to SSW
5 Slopes E of Wind River Canyon, view to SSW
6 Wind River Canyon, view to S
7 Wind River Canyon, view to S
8 Red foothills on N side of Red Canyon Creek, view to N
9 Red foothills on N side of Red Canyon Creek, view to NW
10 W side Nostrum Mtn., view to SSE
11 Red Canyon Crek, view to S
12 Slope SW of Nostrum Mtn, view to SW
13 Big Table Mtn, view to NE
14 Colorful rock outcrop
15 N side of Owl Creek Mtns, view to SW
16 N side of Owl Creek Mtns, view to SW
17 Owl Creek valley, view to N
18 N side of Owl Creek Mtns, view to W
19 N side of Owl Creek Mtns, S Fork Owl Creek, view to WSW
20 N Fork Owl Creek, view to W
21 N Fork Owl Creek, view to W
22 N Fork Owl Creek, view to WSW
23 E side Absaroka Range, Putney Flat, Cottonwood Creek, view to W
24 E side Absaroka Range, Putney Flat, Cottonwood Creek, view to NW
25 E side Absaroka Range, view to NE
26 E side Absaroka Range, view to NW
27 Foothills on E side, Absaroka Range, view to NE
28 Foothills on E side, Absaroka Range, view to NE
29 E side Absaroka Range, view to SW
30 E side Absaroka Range, view to SW
31 E side Absaroka Range, view to SW
32 E side Absaroka Range, view to SW
33 E side Absaroka Range, Wood River, view to SW
34 E side Absaroka Range, Sunshine Reservoir, view to S

Index of Aerial Photos Slides (continued)

ID#: 9805
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 Footslopes, SE side Carter Mtn, view to SW
2 NE end Carter Mtn, view to N
3 NE end Carter Mtn, view to NW
4 Footslopes, SE side Carter Mtn, view to SW
5 Buffalo Bill Reservoir, view to NW
6 Footslopes, NW side Carter Mtn, view to SW
7 Footslopes, NW side Carter Mtn, view to SW
8 S Fork Shoshone River valley, view to SW
9 S Fork Shoshone River valley, view to SW
10 S Fork Shoshone River valley, view to SW
11 SE side Sheep Mtn, view to SW
12 Sheep Mtn, N Fork Shoshone River valley, view to W
13 N Fork Shoshone River valley, view to W
14 N Fork Shoshone River valley, view to W
15 Rattlesnake Creek, Rattlesnake Mtn, view to NW
16 Rattlesnake Creek, Rattlesnake Mtn, view to NW
17 Buffalo Bill Reservoir, view to WSW
18 NE side Rattlesnake Mtn, view to NNW
19 Shoshone River, W side of Cody, view to N
20 Landing at Cody Airport, view to NE
21 Irrigated ag, McCullough Peaks, NE of Cody
22 Cody, Shoshone River, view to WSW
23 E side Absaroka Range N of Cody, view to W
24 Cedar Mtn W of Cody, view to S
25 Heart Mtn, view to N
26 E side Absaroka Range NW of Cody, view to NW
27 E side Absaroka Range NW of Cody, view to NW
28 E side Absaroka Range NW of Cody, view to SW
29 Clarks Fork Yellowstone River, view to NW
30 Mouth of Clarks Fork Canyon, view to W
31 Clarks Fork Canyon, view to WSW
32 Beartooth Mountains, view to NW
33 Beartooth Mountains, view to NW
34 Beartooth Mountains, view to W
35 Beartooth Mountains, view to NW
36 Beartooth Mountains, Foothills, view to NW
37 Beartooth Mountains in Montana, view to NW

Index of Aerial Photos Slides (continued)

ID#: 9806
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 Plains along Charles Fork near Montana border, view to N
2 Plains along Charles Fork near Montana border, view to N
3 Elk Basin Oil Field, view to S
4 Polecat Bench, view to SW
5 Linear cuesta along Dry Creek, view to ESE
6 Cuestas on S side Pryor Mtns, view to NW
7 Gypsum Creek, Bighorn Lake, view to SE
8 S side Pryor Mtns, Crooked Creek, view to NW
9 Bighorn Lake, view to SE
10 Bighorn Lake, view to SE
11 Bighorn Canyon, view to S
12 Bighorn Canyon, view to S
13 Bighorn Mtns, view to ESE from NW of Little Mtn
14 Canyon E of Bighorn River, Pryor Mtns, view to W
15 Bighorn Mtns, view to ESE from NW of Little Mtn
16 SW side Bighorn Mtns, Little Mtn, view to SE
17 Bighorn Lake, Horseshoe Bend, view to WNW
18 SW side Little Mtn, view to E
19 Little Mtn, view to NE
20 Shoshone River entering Bighorn Lake, view to W
21 SW side Bighorn Mtns, view to SE
22 SW side Bighorn Mtns, view to SE
23 SW side Bighorn Mtns, N of US Alt 14, view to N
24 SW side Bighorn Mtns, US Alt 14, view to E
25 Little Sheep Mtn, view to W
26 Badlands S of US Alt 14, view to NNE
27 SW side Bighorn Mtns, Crystal Creek, view to ENE
28 Bighorn Basin NE of Sheep Mtn, view to SW
29 Badlands N of Shell Creek, view to W
•30 Badlands N of Shell Creek, view to W
•31 Badlands N of Shell Creek, view to W
32 SW side Bighorn Mtns, Shell Canyon, view to ESE
33 Shell Creek coming out of Bighorn Mtns, view to E
34 Shell Creek, Shell Canyon, view to ENE
35 Trapper Creek, SW slope Bighorn Mtns, view to SE
36 Trapper Creek, Bighorn Mtns, view to NE
37 Trapper Creek, Bighorn Mtns, view to N

Index of Aerial Photos Slides (continued)

ID#: 9807
Date: 6 Jul 98
Camera: Minolta SRT201
Film: Fujichrome Sensia II 100
Lense: 50 mm
Shutter Speed: 1/250s
Filter: Skylight 1A

1 W slope Bighorn Mtns, S of Shell Creek, view to N
2 Badlands S of Shell Creek, view to NW
3 W slope Bighorn Mtns, S of Shell Creek, view to SE
4 W slope Bighorn Mtns, S of Shell Creek, view to N
5 Red hills, Nowood River, view to SW
6 W slope Bighorn Mtns, Paint Rock Creek, view to NE
7 W slope Bighorn Mtns N of Tensleep, view to NE
8 W slope Bighorn Mtns N of Tensleep, view to NE
9 Cuesta N of Tensleep, view to NW
10 Small canyon in W slope Bighorn Mtns N of Tensleep, view to NE
11 W slope Bighorn Mtns N of Tensleep, view to NE
12 Tensleep Creek, US 16, Wyo 436, view to NE
13 E side Bighorn Mtns, Wyo 436, view to N
14 Canyon Creek SE of US 16, view to N
15 Red Bluff SE of Tensleep, view to SW
16 W side Bighorn Mtns, SE of Tensleep, view to NNE
17 Cuesta N of Spring Creek, view to NNW
18 Red rock and pine S of Tensleep
19 Narrow canyon, W slope Bighorn Mtns, S of Tensleep, view to E
20 Red rocks along Spring Creek Road, view to NW
21 Crooked Creek, Nowood River, Wyo 434, view to NW
22 Wyo 434, Spring Creek Rd, W side Bighorn Mtns S of Tensleep, view to NNE
23 Foothills along W slope Bighorn Mtns S of Tensleep, view to NNE
24 Mahogany Butte on Nowood River, view to S
25 Mahogany Butte on Nowood River, view to NE
26 S end Bighorn Basin, view to NW
27 N slope S Bighorn Mtns, view to W
28 S Bighorn Mtns, view to W
29 S Bighorn Mtns, view to NW
30 S slope Bighorn Mtns, Bridger Mtns, view to WSW
31 S slope Bighorn Mtns, Bridger Mtns, view to W
32 Badwater Creek, view to WSW
33 Vegetation pattern, S of Badwater Creek, view to W
34 S side Bighorn Mtns, Dry Fork Badwater Creek, view to E
35 S side Bighorn Mtns, Dry Fork Badwater Creek, view to ENE
36 Alcova Reservoir, Dam, view to N
37 Freezeout Mtns, view to E

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Bldg. 50
Denver Federal Center
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OFFICE
DATE RETURNED
(Continued on reverse)

GB 428 .W8 R456 1999

Delineations of landtype
associations for northwest